A COST ANALYSIS OF ASSEMBLING

GRAIN BY COMMERCIAL TRUCKS

A Dissertation

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University of Manitoba

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Master of Science

by

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ABSTRACT

Moore, Gerald Wayne. M. S., University of Manitoba, October, 1970. A Cost Analysis of Assembling Grain by Commercial Trucks. Major Professor: E. W. Tyrchniewicz.

In a time when man is travelling to the moon because of his vast technical knowledge and his ability to co-ordinate this knowledge, it seems ironic that some farmers are still hauling their grain to the elevators with a tractor and wagon. In fact in the early sixties, this author knew of a producer still delivering his grain with a team and wagon. The fact that these practices are still evident and part of the system today, suggests that the industry is not keeping with the times.

Grain movement is serviced by a range of vehicles from the tractor and wagon to four and five ton trucks. There are delivery points as close as three miles apart and some over sixty miles apart. There are elevators that range in size from 15,000 bushels capacity, to over 200,000 bushels. It may be true that present decisions in the trade are improving the efficiency of the grain network to a more desirable and economic future, but for years the system has operated on an economic base that was established in 1897 with the "Crows Nest" legislation.

Most of the information for the study is taken from a survey completed in the summer of 1969. There are 45 custom trucks in the sample. The time period under study is the 1967-68 crop year, (August 1, 1967 to July 31, 1968).

Information available from the survey has given considerable insight into the possible programs to solve the rail line abandonment program in the long-run. Rail line abandonment poses serious problems to many sectors of the prairie economy. The effect on producers and grain companies, and numerous other businesses servicing the prairies must be studied in depth, in order that reasonable solutions can be arrived at.

An over-all objective study of grain transportation at the University of Manitoba is intended to develop a rationalized system of grain transportation and handling. One of the specific concerns is to observe what effects and implications rail line abandonment might have on the grain transportation system. The objective of this study is to determine custom trucking costs, and to analyze how commercial trucking can service the grain industry in the event of such abandonment, as well as rationalization in general.

It becomes evident from what is stated above that all areas of our grain handling system need a review. Areas under study at the present time are the following:

1. the cost of hauling grain via farm and commercial trucks
2. the optimum number of elevators and their spatial relations
3. the optimum handling to capacity ratio of country elevators
4. the costs of storing and handling grain, with the costs divided into their respective areas, i.e., handling versus storage costs
5. the economic effects of rail line abandonment.

This study is only one part of a co-ordinated program to study the potential for rationalization of our entire grain marketing system.

The major findings of this study are:

1. The average cost of transporting grain from farms to country elevators by commercial trucks is .29 cents per bushel-mile.

2. The marginal cost of travelling an additional mile after a custom truck is loaded is 38 cents. This is the average of all truck sizes.

3. The average distance commercial truckers haul grain from farms to delivery outlets is 21.78 miles.

4. The average speed travelled by commercial trucks is 31.9 mph. for one and two tons, 34.0 mph. for three tons, and 45.8 mph. for four and five tons.

5. The average labour cost for driving commercial trucks is $1.82 per hour.

6. The method used to calculate depreciation, either diminishing balance or average evaluation does not have a significant effect on the average cost of hauling grain.

7. Theoretically and practically, it may be possible to haul grain without an increase in hauling costs by employing more commercial trucks or larger farm vehicles than is now being done.

CHAPTER I

INTRODUCTION

A BRIEF HISTORY OF CANADIAN GRAIN TRANSPORTATION[1]

The present grain transportation network on the prairies developed over a period of years as a result of expansion of the Canadian railways. Before the turn of the twentieth century, there were virtually no roads. The major source of transportation on the prairies was the railways. The Canadian government at that time promoted railroad expansion by giving monopoly rights to the railways with respect to movement of grain in certain prairie areas. As well as these rights, the government offered the railways free land on which to construct their lines. In 1880, the C.P.R. was given a 20 year monopoly on all lands south of their main line. However, the agreement only lasted until 1888, at which time the government cancelled the monopoly rights to the area and competitive construction of rail lines was allowed. Apparently, the railways felt that it was necessary to construct lines into as many areas as possible, perhaps because the potential of each area was uncertain, or perhaps because of the fear of competition. Whatever the reason, there seemed to be concern on the part of the railways that their future potential revenue could be lost, without branch line expansion.

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[1]For a more detailed description of the development of the grain transportation system in Canada, refer to: Vernon C. Fowke, Canadian Agricultural Policy The Historical Pattern, (The University of Toronto Press, Toronto, 1946).

It was on this scattered network of rail lines, that the country elevators were constructed. The railways themselves were not prepared to build elevators, but they did control the access to the building sites of the elevators. With this control, the railways gave potential elevator builders the assurance that flat warehouse competition would be eliminated. With this assurance, country elevators began to spring up on the Canadian prairies. The elevators were constructed at varying distances from 7 to 20 miles apart.[2] The reason for the mileage spacing was the farmers' inability to transport grain over long distances. His mode of transportation at that time was the team and wagon. The mileage interval left between elevators, meant that producers were required to haul their grain a maximum distance varying by shipping point from 12 to 15 miles from their farms. It should be understood that while the distances in some areas were as high as 15 miles, there were also areas where the maximum distance was only 5 or 6 miles. In the railways' construction program of branch lines, they seemed to overlook the long-run inefficiencies created in closeness of the lines in many areas. Perhaps many lines need not have been constructed.

As motor carrier transport increased with highway and road improvement, the monopoly effectiveness of the railways as a transportation service diminished on the prairies. Its inability, or reluctance to adapt, or government restrictions which did not allow them to adapt and compete with trucks, soon put the railways in difficult circumstances with regard to freight services to the great majority of towns, villages

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[2] W. A. MacKintosh, Prairie Settlement (Toronto: The MacMillan Company of Canada, 1934), p. 55.

and hamlets throughout the Prairie Provinces. However, railways are still the largest transporter of grain out of prairie delivery points to terminal destinations at Vancouver, Churchill, and Thunder Bay.

In recent years, rising costs have forced the railways to consider abandonment of many of their low traffic lines. Abandonment of rail lines on the prairies creates numerous problems for prairie towns and villages, but more specifically to the grain industry.

STATEMENT OF THE PROBLEM

It can be expected with some degree of certainty that the railways will continue to apply to the Canadian Transport Commission for the abandonment of many of their branch lines. In fact, it may be fair to say that in the future the entire rail network may be shortened by the miles requested for abandonment by the railroads. This statement is based on the premise that railways will not be forced by government to operate branch lines at a loss if a reasonable alternative for the movement of grain is found. If this is the case, then an alternative program is required to fulfill the function of the abandoned branch lines.

There are several questions which might be raised at this time, with regard to the railways' request to abandon these uneconomical branch lines:

1. If grain is the only commodity moved on these branch lines, would it be feasible to use commercial trucks to transport the grain to larger collection centers? There are two aspects to this suggestion: (a) Local elevators may be kept open (assuming that necessary changes

in regulations are made) with farmers delivering their own grain in the manner in which they do now, and commercial trucks be used only to move the grain from that point to another point serviced by the railroad.
(b) The point could be closed entirely and commercial trucks utilized to haul farm grain to larger points on higher density lines. It is possible that two-way hauling[3] would be impractical. This may come about because at the time that the grain is delivered, there is no backhaul of goods to the farm. Therefore, trips made by commercial trucks could be a one-way load with an empty return.

2. What would be the actual costs of moving grain by commercial trucks as compared to the present system of grain movement?

3. With the railway requesting the abandonment of certain lines, how efficient would a commercial trucking operation be as a complete or partial replacement?

4. Would a network of commercial trucks add flexibility to the system that is not now present?

5. Would farmers themselves accept the opportunity to do custom or commercial trucking as a sideline to their present duties? What would be the required outlay to become established in such an operation and what costs would be levied to the producers serviced? Is there a possibility of subsidy for moving grain by truck?

The freight rate on Canadian grain movement by rail has been regulated by the Crows Nest Pass Agreement established in 1897. Since that time, these rates have been the guideline prevailing over all grain

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[3] Two-way hauling is the trucking of goods onto the farm while moving the grain off the farm to country elevators, i.e., the truck is loaded travelling both to and from destinations.

movements by rail. In recent years, the railroads have requested the abandonment of the mileage of track which they maintain is too costly to operate. In view of the problems created by rail line abandonment, it is apparent that a suitable alternative to rail must be explored. It would appear that trucking facilities may play a more vital role in the movement of grain in the prairie grain transportation network.

If we assume that commercial trucks can play a role in this network, then it should be of interest to the grain industry at large, to have specific cost figures with relation to the operation of custom or commercial trucks. The grain transportation problem on the surface may appear quite straight-forward but there are many ramifications which become evident by considering the following questions.

1. What is it presently costing farmers to haul grain in commercial vehicles to the local elevator or feed mill?

2. What would be the increase in costs incurred by farmers to haul grain greater distances if rail lines are abandoned?

3. Does the type of road conditions have a direct bearing on the costs incurred by truck operators, and to what extent? (Road conditions include paved, gravel, and earth surfaces.)

4. What size of truck would give the cheapest and most efficient service to the owner of the truck and to the producer?

5. Does the age of the truck have a direct effect on the cost of the commercial trucking operation?

6. How should the remaining elevator points be best utilized after abandonment? The problem here is to optimize grain flow patterns and to minimize truckers' time losses due to bottlenecks in the system of movement. Events to consider here would be long line-ups at elevators,

and minimization of the distance travelled.

It should be pointed out that distance minimization may not be the reason behind a producer's selection of a grain delivery point.[4] If a producer wishes to choose a point on grounds other than the minimum cost of grain delivery, it is his privilege to do so. However, this study will not be concerned with the sociological or personal preferences of individual producers. The main criterion will be to identify economic efficiencies and costs of commercial trucking of grain from farms to country elevators. In order to attain this objective, it is assumed that producers base their deliveries on the minimum cost of delivery.

PREVIOUS STUDIES OF THE COST OF MOVING GRAIN BY TRUCK

Previous analyses of farm truck costs have generally estimated an average cost of one-half cent per bushel-mile. Young, in a study conducted in 1966,[5] determined the average cost of hauling grain from farms to country elevators to be this value. This cost figure has also been estimated as the Saskatchewan custom rate for

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[4] E. B. Riordan, "Spatial Competition and Division of Grain Receipts Between Country Elevators", (Unpublished Master of Science Thesis, University of Manitoba, February, 1965).

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

the hauling of grain.[6]

Riordan stratified trucking costs for grain movement on the basis of the type of road surface travelled.[7] The costs for one mile of travel by farm trucks according to road surface were estimated as follows: paved 6.5 cents, gravel 8 cents, and earth 10 cents.[8]

These cost figures are based on farm trucks. It would seem apparent from the literature that the cost figure of one-half cent per bushel-mile is a reasonable estimate of the cost of moving grain by truck. However, when the rates charged by farmers to their neighbours, or by truckers to the farmers, are examined, the rate is frequently below that of one-half cent per bushel-mile.

Based on the rates now being charged by truckers, there is considerable doubt as to the validity of one-half cent per bushel-mile being the actual cost of moving grain by truck from farms to the country elevators. It seems apparent that the average cost of hauling grain by commercial truck now is not what has been expressed in the previous literature for an earlier time period.

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[6] Custom Rates Per Acre in the Province of Saskatchewan as Shown by Mail Questionnaire Survey Through Wheat Pool Locals, (Department of Farm Management, University of Saskatchewan and Dominion Economics Division, Saskatoon), p. 2.

[7] E. B. Riordan, op. cit., p. 49.

[8] Ibid.

SCOPE

The movement of grain from the farms to the country elevators is an integral part of the grain transportation system. Savings may be incurred in this sector which could in effect, assist in the rationalization[9] of the entire grain transportation network. The new determination of costs of moving grain by commercial trucks at this later period in time, could shed new light on optimum economic distance between elevators. Such cost information could be an important factor in assessing the feasibility of abandoning many of our branch rail lines.

Previous studies have indicated the costs of grain hauling by farm trucks. This study attempts to explore commercial trucking costs. This study is primarily an economic approach and will give results only of an economic nature.[10] A parallel study on the cost of moving grain by farmer owned trucks is presently being undertaken by A. H. Butler.[11]

Information relevant to the determination of actual grain hauling costs was derived directly from information obtained in a sample survey of custom and commercial truckers. An attempt was made in this study to rely as little as possible on previous studies for data.

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[9] Rationalization means to create a sounder economic structure in which to operate.

[10] Problems of a political, sociological, and personal nature resulting from the movement of grain over longer distances by truck are recognized as being important; however, an analysis of these problems is outside the scope of this thesis.

[11] A. H. Butler, "A Cost Analysis of Transferring Grain by Farmer Owned and Operated Trucks", (Master of Science Thesis unpublished, University of Manitoba, Winnipeg, 1970).

HYPOTHESES AND ASSUMPTIONS

The null hypothesis that the cost of hauling grain was equal to .5 cents per bushel-mile, was tested by the data from the sample survey used in the study.

The actual costs involved in grain movement is dependent on several factors. The values placed on these factors will determine whether the null hypothesis is accepted or rejected. The factors to consider and their hypothesized impact on costs are as follows:

1. Average transportation costs are related to the size of the truck. The larger the truck, the lower should be the average cost per bushel-mile.[12]

2. Average transportation costs are related to the number of miles travelled per haul. The greater the number of miles, the lower should be the average cost per bushel-mile.

3. Average grain transportation costs are related to the type of road surface travelled (i.e., gravel, earth, and pavement). The better the road surface, the lower should be the average cost per bushel-mile.

4. Average transportation costs in any given area are related to the volume of grain a trucker is able to transport. The larger the volume, the lower should be the average cost per bushel-mile.

5. Average transportation costs are related to the age of the truck. The older the truck, the lower should be the average cost per bushel-mile.

6. Average transportation costs are related to the total

[12]The bushel-mile is defined as the movement of one bushel of grain over the distance of one mile.

number of miles on the truck. As the truck accumulates more miles, the costs are expected to increase.

Not all factors affecting the cost of grain movement by truck are easily or empirically obtainable. However, it may be possible to take these variables into account with the assistance of the following assumptions.

1. It is assumed that the sales market for the trucks is homogeneous in the prairies other than for freight differences. It becomes necessary to assume this to derive an average price for the purchase of commercial trucks. That is, a three ton truck in Calgary should have the same market value as in Winnipeg other than for the freight cost difference.

2. We assume that the trucker will not haul any grain unless his box is loaded to full capacity. Boxes loaded to less than full capacity would distort the revenue received from the service and would directly increase the costs on the basis of a bushel-mile.

3. It is assumed that truckers are faced with a one-way haul. Generally there will be no return movement of goods from the elevator to the farm. It may be true that in some instances, return of feeds or fertilizer or other commodities are made, but these movements are very limited.

4. This study assumes that trucks of a commercial nature, whether purchased and operated by a farmer or a commercial trucker, are used for other purposes besides the hauling of grain. The nature of the other operations are examined in order that an equitable distribution of costs can be debited to each operation. If a truck has been purchased by the trucker for the hauling of grain only, then the total

cost of the truck is allocated accordingly.

ORGANIZATION OF THE THESIS

The remaining chapters of this thesis are organized in a manner that is intended to effectively bring together all the implications of the research. Chapter II describes the theory relevant to transportation as used in this study, and also shows the conceptual considerations of the different cost variables. The results of the analysis are outlined in Chapter III. Chapter IV contains the conclusions and implications. The area studied, a review of previous literature, the formulas for calculations of the cost variables, and a series of cost tables, are found in the appendixes.

CHAPTER II

COST THEORY

DERIVING THE AVERAGE COST FUNCTIONS

A cost model for the motor carrier industry will consist of several factors. These factors, as will be shown later in this chapter, can be divided into fixed and variable costs. This study covers a period of one year and from the standpoint of economic theory, is considered to be short-run. Thus, it is necessary to differentiate between fixed costs and variable costs. The fixed costs are those costs that are incurred regardless of the number of miles or hours a truck operates. Cost items such as depreciation, insurance, license, and interest on investment, may be considered as fixed costs. The major short-run variable costs for trucks are the amounts paid for fuel, labour, and repairs.

In this study, mileage is the main base on which all average costs are determined. Costs are estimated on the basis of the bushel-mile. The bushel considered in the analysis was wheat, which has a weight of 60 pounds for statutory purposes.

Some modification of the conventional theory[1] is necessary, in order to illustrate unique factors connected to the transportation industry. In theory, AFC[2] decreases as the miles travelled increase. The decline in AFC is explained by the fact that as the work load units are increased, the fixed costs are divided among a greater number of output units. (Work

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[1] C. E. Ferguson, Microeconomic Theory, (Richard D. Irwin, Homewood, Illinois, 1966), Chapter 8.

[2] AFC - average fixed cost.

load units in this case are the miles of haul.) However, there are some exceptions to the conventional theory. The decreasing AFC only remains true if the miles of haul can be satisfactorily handled by the same vehicle or vehicles. If more vehicles have to be purchased to handle the trade, we can get the following effect:

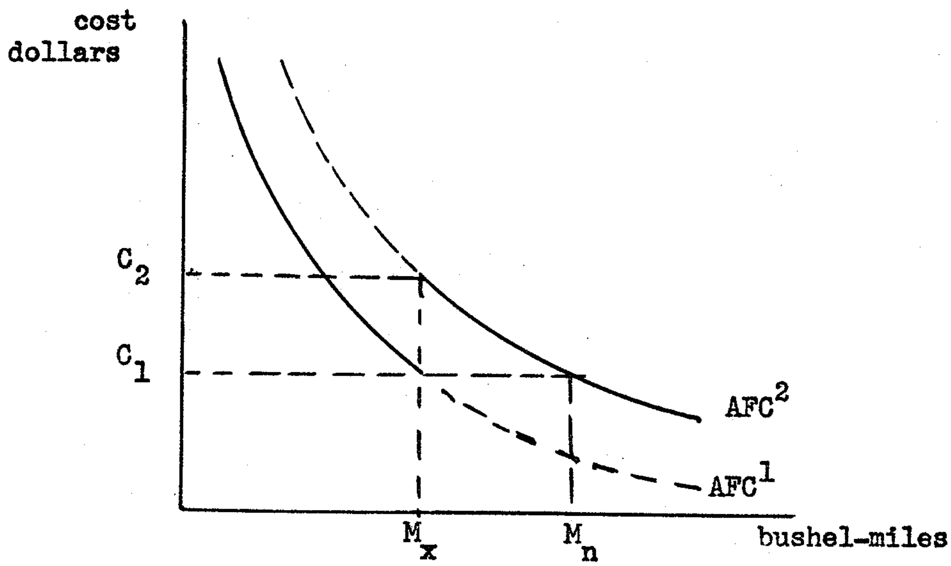

Figure 1

The Effect on AFC of Purchasing an Additional Truck

When M_x miles are reached with a given vehicle, it is physically impossible to travel any further, either the vehicle is operating twenty-four hours a day, or another truck driver and truck are required to operate in the day time work period, e.g., 8 A. M. to 6 P. M. In any case, capital outlay is required at M_x to service the extra business which entails driving M_n miles. Thus, at mileage M_x the entrepreneur is compelled to purchase another truck to service his potential, additional business.

Correspondingly, the new AFC rises from AFC[1] to AFC[2]. In this way, M_n is reached at a similar AFC of C_1. The number of work units or miles increased to reach point M_n at the cost C_1, which was the original mileage point M_x at cost C_1. The cost of a new truck is incurred in one time period to benefit several following periods. The concept of cost based on miles does reduce the problem of high incurred costs over a short-run period. The AFC depends on the miles driven in the given period.

Average variable costs incurred in the trucking industry may be explained in the following manner. Variable costs of trucks are theoretically dependent in total magnitude upon the amount of use or number of miles driven in a short-run period. The concept of variable in respect to these costs, refers to the behavior of the costs when output changes and has no relationships to changes in the cost figures due to variation in costs per unit of factor.

Conventional theory depicts the average variable cost as convex downward. The shape of the curve is derived from the shape of the total variable cost and is found by dividing the TVC[3] by miles. However, this curvature of the conventional average variable cost curve does not seem consistent with transportation models. After a truck is loaded and underway, the cost for each successive mile should be the same as the previous one. That is, variables such as fuel cost, wages, etc., should be the same for one mile as another. This of course assumes similar speed, load, and road conditions. If conditions are as suggested here, the AVC would be a horizontal line. (Figure 2). The costs incurred during loading and unloading are treated as deadhaul costs. These costs act in the same manner as the fixed costs, decreasing as the hauling

[3]TVC - total variable cost.

distance increases.

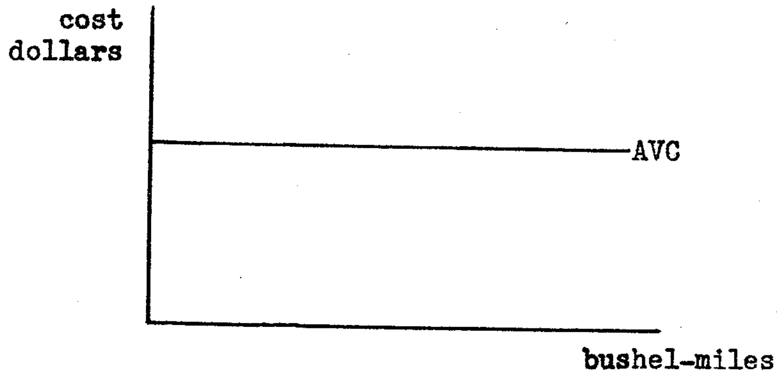

Figure 2

AVC for Trucks in the Short-Run

In the long-run, it may be argued that the AVC will begin to increase as the truck becomes older and the mileage travelled increases. However, for purposes of this study, it should be safe to assume that any increase in AVC will be so small that it could be neglected.

The conclusions taken from the theory are that the AFC is downward sloping, and the AVC is horizontal. Combining the two cost functions we derive the ATC which can be illustrated as follows:

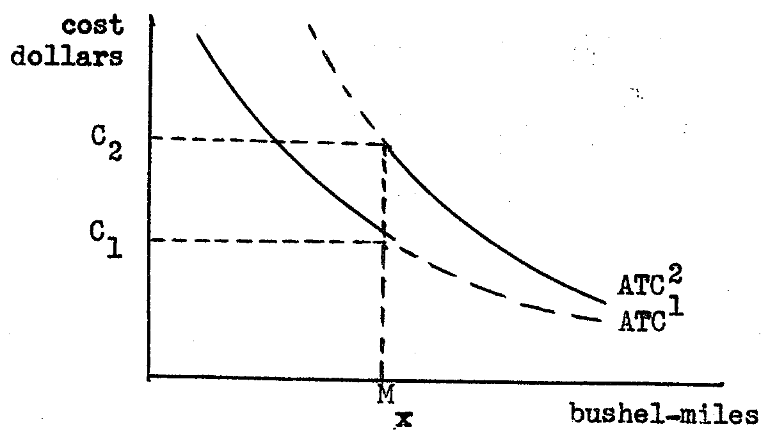

Figure 3

The Effect on ATC of Purchasing an
Additional Truck

ECONOMIES OF TRUCK SIZE

Theoretically, the size of the truck should have a direct effect on the average cost curve of moving grain. Although the shapes of the curves may be similar, different sized trucks will show different ATCs over various mileages. The relationship of the cost curves of different sizes of trucks will depend on the mileage travelled. The following example explains the relative average cost curves of two trucks of different sizes.

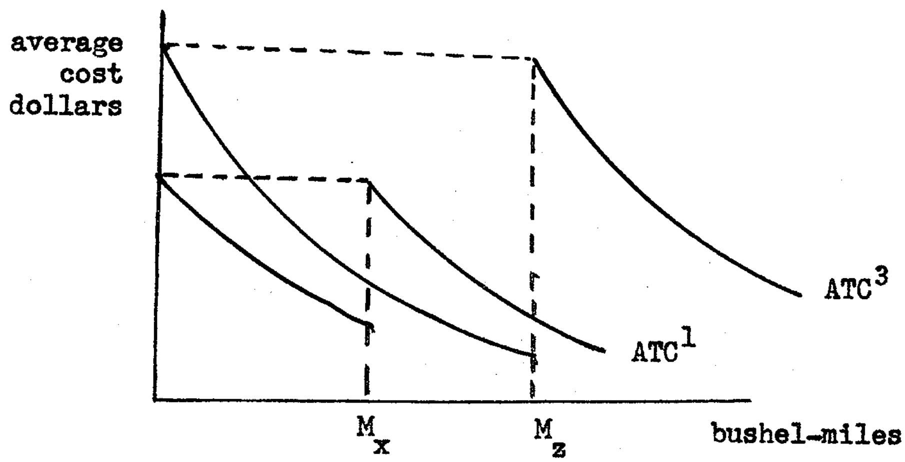

Figure 4

The Relative Average Total Cost Position of Different Sized Trucks for Different Bushel-Miles

The cost line ATC^1 in Figure 4 represents the average cost curve of a one ton truck, and ATC^3 represents the average cost of a three ton truck. Similar cost relationships should appear between all sizes of trucks. The smaller vehicles in this case cost less per bushel-mile than the larger. However, there may be a range of bushel-miles as shown by M_x up to M_z where the smaller truck would be more expensive than the larger. This occurrence may be caused by the difference in load size.

After bushel-mileage M_x, it may be impossible to haul more without another truck, while the larger vehicle may be serviceable up to M_z bushel-miles. The extra average cost of the operations of the smaller vehicle from M_x to M_z cannot really be charged to the operation of a one ton truck, but rather to its limited load capacity, which necessitates the purchase of a larger truck or second vehicle. It is important to note that the variation in the cost curves is dependent on the average size of the load, and more importantly on the miles of travel. Larger loads mean that fewer trips are required to move a given volume of grain. The larger trucks can display economies of scale if the volume of grain to be moved and the miles to be travelled warrant large truck service.

THE OUTPUT UNIT

To this point little mention has been made of the actual output unit supplied by the motor carrier industry to the grain shipper. It was mentioned earlier that the service output unit was a bushel-mile. When conventional cost theory is employed, a homogeneous unit of output is assumed. However, in transportation a problem arises when we make this assumption, because each unit of output (bushel-mile) is not necessarily the same. There will definitely be differences in cost, attributable to quality variations in the bushel-mile. A truck travelling on a paved surface versus one travelling on an earth or gravel surface, is not providing a homogeneous service. It would be expected that the service of moving a bushel-mile over an earth or gravel road would be more costly than travelling over a paved road. Another qualitative consideration of output is the terrain; a truck hauling through rugged topography may have different cost considerations than one travelling on a level plain.

The effect created by variations in the quality of service develops a third dimensional aspect to the cost of a trucking firm. Figure 5 illustrates that the cost of service provided by the trucker varies depending on the type of road surface. Assume in this case that an entrepreneur owns three trucks of a standard size, make and age, i.e., homogeneous trucks. Each truck is designated to provide grain hauling services on a given type of road surface. Truck number one is assigned all the paved roads, truck number two all the gravel miles, and truck number three all the earth miles. In theory, the costs incurred at any specific mileage should be greater for truck number three, than truck number two and one, respectively. The reason for the increased cost on the poorer road surfaces can be explained by several factors:

1. A deteriorated road surface causes a reduction in speed which increases labour costs.

2. A poor road surface causes more rapid tire wear.

3. Poor road surfaces cause excessive vibrations of the vehicle which directly affect repair costs.

4. A poor road surface could cause excessive fuel consumption.

A further elaboration of road surface and their effect on costs can be found in Appendix C.

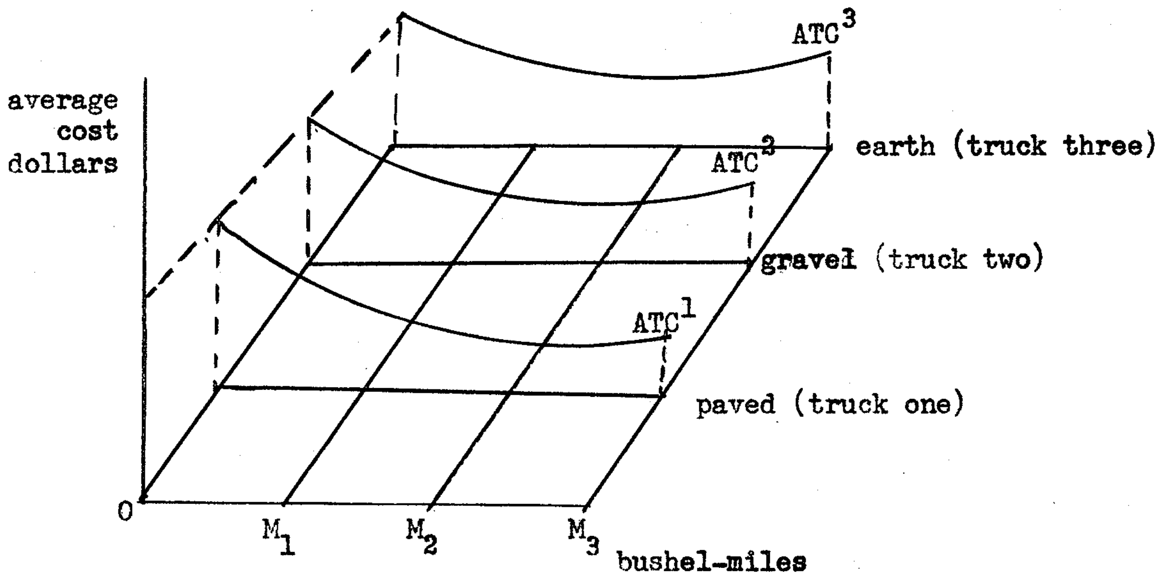

Figure 5

The Effect of Road Surfaces on the Average Cost of Driving Trucks

The afore-mentioned cost factors attributed to road surfaces, illustrate why producers on poorly surfaced roads may be expected to pay a higher rate for movement of their grain than producers located on good roads. It can also be assumed that cost differences can come about by other quality differences, such as rugged terrain, or hilly countryside. What should be stressed is the fact that the demand unit to the shipper is the same in one region as the other, while the service being supplied by truckers is not the same. The difference in the service provided to haul an output unit (bushel-mile) is created because of quality differences.

Further, it should be pointed out that the cost of moving one bushel 100 miles is substantially different than the cost of moving 100 bushels one mile. In the context to be used in this study, the bushel-mile is defined with the intent to show <u>volume</u> as being the prime consideration of the output unit, i.e., 100 bushels per mile. Because costs are charged against the volume of output moved, it is necessary to consider vehicles as being fully loaded, in order that distributions of cost make sense. By using a hypothetical example, this point should become clearer. Assume that it costs $10 to travel 100 miles with one bushel loaded on a truck. Further assume that it costs $10 to haul 100 bushels a distance of one mile. In the first instance, the cost of moving the one bushel of grain exceeds the value of the commodity ($2), and has no sensible value of service to the shipper. In the second case, the cost of service is 10 cents per bushel, a cost well below the value of the commodity. In this case the output unit has a relevant meaning to both the shipper and the commodity he wishes to ship.

CONCEPTUAL CONSIDERATIONS IN THE TREATMENT OF FIXED AND VARIABLE COSTS

Over a long period of time all costs are variable and can be adjusted. However, for this study a one year time period was selected. This choice allowed for both fixed and variable costs to be present in the analysis. There are two major categories of fixed costs. The first category of costs are of a recurrent nature, involving an actual outlay of money, during the short-run period. The second category of costs are known as allocable fixed costs. These consist of long-run capital expenditures allocated over several periods of use. For example, the cost of a new truck is normally incurred at one time for the benefit of use during several following time periods. Included in the recurrent fixed costs are such items as license fees and insurance. The allocable fixed costs include depreciation, interest on investment, and possibly some major repairs. For example, the replacement of a motor in a truck may make the vehicle serviceable for 100,000 miles, and therefore, should be charged against more than the time period under study, unless the 100,000 miles are driven within the given time period.

Variable costs on the other hand, depend directly on the number of miles of operation. Cost factors such as labour, fuel, grease, oil, repairs and tune-ups, vary directly with miles of service.

To insure that the cost data are understood in a sound theoretical manner, the following discussion will attempt to justify the methods selected in the analysis. Each cost variable is evaluated in turn in a theoretical context.

FIXED COSTS

The following costs are treated as fixed costs in this analysis: purchase price of truck, insurance, license, truck housing, utility costs and management. The rational for treating them as fixed costs is presented below.

Purchase Price of Trucks

The outlay of capital for the purchase of a new truck should be credited to the number of periods over which the truck is used. The cash expenditure for the purchase of a new truck is incurred to reap the benefits over several following time periods. To assess the proper portion of the capital outlay to a given time period requires an analysis and calculation of the purchase price, with regards to its correct allotment to the specific period under study. A major portion of the fixed cost for the given year will depend on the depreciation assessed to it.

One must also take into account the resale value of the vehicle and the time at which it was sold. The actual fixed cost charged to the 1967-68 crop year will be dependent on the depreciation assessed to that period. Further discussion of depreciation cost is forthcoming under the heading of depreciation.

There is one further case which should be looked at with regard to the purchase price of trucks. This case is where trucks are purchased on credit. It is apparent that the capital outlay at the time of purchase is substantially reduced in the "buy now pay later program". However, it can also be asserted that the return on the investment will make up for the interest on the purchase loan. In the final analysis, the fixed cost credited to the specific time period would be exactly the same whether the truck was purchased for cash or on credit, provided the interest rates in both cases are equal.

> We know that the cost of the firm's "fixed" factors in each period is made up of, (a) the payments that have to be made in each period, by way of interest and dividends on monies that were used to buy them, and (b) the depreciation which in its turn depends on the expected life of the fixed factors, their prices and the rate of interest that the firm can earn on the sums of money set aside for depreciation while they are being accumulated to finance replacement.[4]

The price paid for the purchase of a truck is such a "fixed" sum and the cost assessed against a given period will be arrived at by calculation of the depreciation.

Insurance

Insurance on comparable vehicles of similar yearly mileage, doing a similar job, should be the same. However, variations do arise.

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[4]W. J. L. Ryan, Price Theory, (Fellow of Trinity College, Dublin, St. Martin's Press, New York, 1967), p. 310.

Insurance rates for the truckers vary greatly in response to such items as record of drivers, type of road, type of load, length of haul, and the type of insurance carried.[5]

The insurance premiums paid for 1967-68 crop year are fixed in value and as such are a fixed cost. In the analysis, insurance costs are treated as fixed costs and are averaged for similar sizes of vehicles.

License

Another recurrent fixed cost is license fees. For the average trucking firm, license fees are the same regardless of output or miles. The reason for the fixity of license charges comes about because the firm applying for the license must stipulate the type of trucking operation desired, i.e., commercial, farm truck, etc. A large variation in the actual cost of the vehicle license is dependent on whether a trucker has a P.S.V.[6] license, a standard truck license or a farm license, the costs range from high to low, respectively, in that order. Public Service Vehicle licenses are required by commercial truckers by law. These licenses allow for movement of goods over longer distances and also carry some manditory insurance clauses. Regardless of the actual cost of a license, by theoretical definition, licenses fall in the category of recurrent fixed cost - recurrent, meaning that it must be paid each and every year in order to operate a truck.

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[5] K. L. Casavant and D. C. Nelson, An Economic Analysis of the Costs of Operating Grain Trucking Firms in North Dakota, (Department of Agricultural Economics, Agricultural Experiment Station, North Dakota State University, Agricultural Economic Report No. 54, Fargo, July, 1967).

[6] P.S.V. - Public Service Vehicle.

Truck Housing

Previous studies have found evidence that the majority of vehicles are not housed. Young, in his study in Manitoba found, "that only 16 out of 69 farm trucks taken in the sample were protected from the weather".[7] Having found no evidence to support the thesis that housing for trucks is a necessary cost, Young decided that no charge should be incorporated into his analysis. However, for this study it was decided to determine how many trucks are housed and subsequently - what does it cost? One aspect of this study is to determine if housing costs are significant.

In theory, the cost of truck housing can be determined in a similar manner to the purchase price of the truck. The method employed in this research is to charge the yearly depreciation as a fixed cost. In this case, it was the 1967-68 crop year. Incurred repairs in this period are charged as an allocable fixed cost and charged to the life of the building. The actual empirical values assessed can be found in Appendix E.

Utility Cost

When analyzing telephone costs, it becomes apparent that they can be considered partially fixed and partially variable. This double categorization comes about from the fact that telephones have a basic charge. Further long distance charges to the business would be considered variable and would be dependent on the number of calls, time on the line, and the distance of the call. In this study the amount of cost incurred by long distance calls is negligible and for this reason

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

telephone costs are entered only as fixed costs.

Hydro and fuel to heat the building are also treated as fixed costs because they remain constant, regardless of the use made of the vehicle. It can be argued that hydro used to plug in truck block heaters in the winter is a variable cost. The reasoning behind this argument is based on the assumption that the trucks are only plugged in prior to being used and not at all times during severely cold weather. In cases where trucks are continuously plugged in and not used, it is difficult to assess the cost as variable, because there are no miles to assess the charge against. The method employed in this analysis is to assess all hydro as a fixed cost. The relatively small portion of total cost that hydro represents in this study, and the lack of information required to assess hydro as a variable cost, suggest that the sensible approach is to consider hydro as a fixed cost.

Management

In most cases, the return to management for an owner-operator grain trucking operation is undetermined. There is no attempt by the individuals concerned to separate costs of management from costs of labour. Management costs should be looked at as opportunity costs in light of the fact that salaries would be received by working for other firms in a similar capacity. In an owner-operator trucking business, the costs of management are considered as fixed, although returns to management may vary with the usage of the vehicle. The costs applied in such an operation will remain fairly stable. Because of the small nature of the owner-operator grain trucking business, there is no room for management as a consideration separate from the other aspects of the operator's functions. For this study, there were no data available to make an attempt to determine management costs. However, there is information available on labour, which for the most part can be accounted for as a cost. Because grain truckers make no distinction between management and labour, the management and labour costs have been grouped as one, under labour. To the grain trucking entrepreneur, management and labour are synonomous.

VARIABLE COSTS

The preceding topics have all represented fixed costs. The variable costs are those costs dependent on production and in this research, the costs will be dependent on the miles of operation. The costs considered variable in this analysis are: tires, batteries, lubrication, repairs, fuel, and labour.

Tires and Batteries

The costs incurred by cash outlays on tires and batteries are directly proportional to the number of miles of service. In this study the cost of these repair items are arrived at by averaging the expenditures over the number of vehicles in the sample. To base the cost of tires and batteries on the mileage travelled would result in a more accurate calculation. Average yearly tire costs are being used because of the number of vehicles in the sample, and also because these vehicles are in all areas of the mileage spectrum. The actual costs for the tire wear per mile were determined from the data and are found in Appendix C, Table 4. These costs were determined to point out that custom grain truckers' tires are worn more through usage than aging. In the case of farm trucks, it has been said by many farmers that the tires will last the life of the truck. In such cases, deterioration of the tires comes about as much by aging as mileage. In the Casavant and Nelson study in North Dakota, it was estimated that the average truck tire life was 100,000 miles.[8] If a farm truck only travelled 5,000 miles per year, the tires could theoretically last 20 years, which would be the life of the truck.

Lubrication

Grease and oil costs vary directly with the annual mileage. The price of oil or grease is not the variable factor under consideration, but rather the variation in the volume used.

Repairs

Truck repairs create some unique problems. For example, it becomes difficult to differentiate between the small tune-up jobs that enable the truck to function better for five to ten thousand miles, and the major overhauls which may increase the truck service by another 50,000 miles. While it is true that the initial cost in both cases is incurred for future operation of the vehicle, it is impractical to attempt to assess each repair bill against some specific mileage. However, one can take a given time period, assess the mileage travelled by a number of vehicles of a comparative size in that period, and assess repair costs on an average.

The reason for taking this approach is to reduce the possibility of extremes in repair costs, that may bias the answer upward or downward. The risk of these biases in determining costs is reduced when a larger sample is used and similar mileages are accounted for. This analysis

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[8] K. L. Casavant and D. C. Nelson, op. cit.

assesses costs for a yearly period of all trucks. It also separates larger mileage vehicles. The reason for the separated approach is to isolate higher mileage vehicles for purposes of repair cost comparison.

Fuel

A major cost to a trucking operation is the cost of fuel. The variation in price paid for fuel is eliminated by using an average price. The average price is determined from the prices submitted on the questionnaires. Fuel consumption is directly related to the number of miles travelled, and therefore fuel costs are variable costs.

Labour

Labour costs in the study are variable costs which are dependent on the number of repairs to the vehicles and the hours and miles the trucks are in service.

1. The labour to keep the vehicle in repair and serviceable - this is labour maintenance and repair work.

2. The labour required to drive the grain trucks while in the process of moving, and also the waiting and loading time of the driver.

The problem in this area was to determine a reasonable figure for the actual cost of a skilled truck driver who is also a manager and mechanic. The nature of the owner-operator grain trucking business seems to demand that the individual be qualified in all three areas. This position was substantiated by most of the operators contacted in the survey. Grain truckers take the view that being able to repair their own facilities is a considerable cost saving factor. To determine the actual wage that entrepreneurs require as a labourer to their operation, the average wage rate of all the individuals in the sample was accepted.

DEPRECIATION[9]

Depreciation as a cost factor of trucks is a most important one. As a cost, depreciation is viewed as being fixed for two reasons: first, over a period of a year the amount of truck life used up will be reasonably constant as far as price devaluation is concerned; second, the loss in value is incurred whether the vehicle is used a great deal or not.

> Depreciation involves pro-rating the original cost of an asset over its useful life. The amount of depreciation charged should correspond to the loss in value of the asset over time. The original cost is a prepaid expense. However, if the asset will be used in more than one accounting period, this cost should be allocated to those accounting periods that correspond to the productive life of the asset.[10]

In an attempt to arrive at the most reasonable method to assess depreciation, the declining balance and a modified re-evaluation method were studied.

The Declining Balance Method

A constant rate of depreciation is used every year. The rate is applied to the value of the asset at the beginning of the year, and is applied to the uncovered balance until the salvage value is reached. The salvage value is not subtracted from the cost and when it is reached, no further depreciation is taken.

Re-evaluation

With this method the asset is re-evaluated as to worth at the end of every period. The difference between the initial and final worth is

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[9] For a full review of depreciation see: E. N. Castle and M. H. Becker, Farm Business Management, (The MacMillan Company, New York, 1962), p. 74.

[10] Ibid.

the depreciation. There have been many controversies about the best method of assessing depreciation. Each method has advantages and disadvantages in accounting procedures. In this study, it was decided that a comparative analysis of the two methods would be undertaken.

The Average Method

Depreciation in the market place is not always based on accounting principles and economic theory. There are cases where trucks are depreciated by the diminishing balance method, to a "book value", which is lower than the vehicles can be purchased or sold for on the market. In such cases the book value would reflect greater depreciation costs than had been actually incurred. A further explanation and example can be found in Appendix C. Because of this weakness of the diminishing or declining balance method, a modification of the re-evaluation procedure was applied to adjust such discrepancies. The major difference with this approach called the average method, is that the initial price of the truck is applied to the present price, and the difference between the initial and final price is divided by the number of years in the interim period. Thus, the average is found and can be applied to the year under study, in this case the 1967-68 crop year. The results of the comparison of these two methods of calculating depreciation can be found in Appendix C, Table C2.

THEORETICAL DEVELOPMENT OF THE TRUCKING MODEL

Nine independent variables are hypothesized to determine the greatest portion of commercial grain trucking costs. These independent variables are expressed in the following manner in relationship to the dependent variable - trucking costs.

1. The average cost per bushel-mile decreased as the size of truck increased.

2. The average cost per bushel-mile decreased as the total truck miles, per year, increased.

3. The average cost per bushel-mile decreased as the loaded trip miles increased.

4. The average cost per bushel-mile decreased as the load size, in bushels, increased.

5. The average cost per bushel mile increased as the road surface deteriorated, that is, as the percentage of earth and gravel miles increased.

6. The average cost per bushel-mile decreased as the age of the truck increased.

7. The average cost per bushel mile decreased as the volume of grain hauled increased.

8. The average cost per bushel-mile increased as the labour requirement per bushel-mile increased.

9. The average cost per bushel-mile decreased as the proportion of miles hauling grain increased.

To derive a quantitative relationship between the dependent and the independent variables the linear model used was as follows:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8$$
$$+ b_{10}X_{10} + b_{11}X_{11} + E$$

Y = cost in cents per bushel-mile

a = constant

b_i = regression coefficients (i = 1, 2, - - - 11)

Earth and gravel miles were originally shown as separate variables X_5 and X_6 respectively. In the final analysis they were combined as variable X_9.

X_1 = size of truck

X_2 = total yearly miles

X_3 = one way haul in miles

X_4 = load size in bushels

X_5 = percent of earth miles

X_6 = percent of gravel miles

X_7 = age of truck

X_8 = yearly grain volume in bushels

X_9 = percent of earth and gravel miles

X_{10} = labour costs

X_{11} = proportion of total yearly miles hauling grain

E = random error

It was hypothesized that b_i (i = 1, 2, 3, 4, 6, 7, 8, 11) were less than 0 and b_5, b_6, and b_{10} were greater than zero. The model will be fitted to both the actual data and the Cobb-Douglas transformation of the data. The form yielding the best fit will be used to test the hypotheses regarding the regression coefficients.

CHAPTER III

RESULTS OF THE ANALYSIS

The previous chapters have established the background theory used to establish the required information for this study. In this chapter, the empirical results will be observed as they were calculated, based on the survey data. All the information referred to was taken from the 1967-68 crop year.

Results of the Cost Analysis

Fixed and Variable Costs

It was found that with one and two ton trucks, the fixed costs accounted for 50.5 percent of the total costs, and the variable costs accounted for 49.5 percent. With the three ton trucks, the fixed costs accounted for 23.5 percent of the total costs while the variable costs were 76.5 percent. The four and five ton vehicles showed average fixed costs as 23.4 percent of total cost and variable costs at 76.6 percent. However, custom and commercial vehicles are utilized for other services than the hauling of grain and these services vary from truck to truck in various proportions to total output. The cost of hauling grain was isolated from the other services provided by the trucks. This was done by calculating what percentage of total yearly miles were used to haul grain. The yearly grain miles were then assessed that portion of the costs that were debited to them. These weighted cost percentages looked as follows:

Table 1. Percentage of Variable and Fixed Costs for Various Sizes of Trucks

Truck Size	Fixed Costs	Variable Costs
1 and 2 tons	44.8 %	55.2 %
3 tons	39.4 %	60.6 %
4 and 5 tons	26.6 %	73.4 %

A breakdown of the costs weighted to grain, can be found in Appendix C, Table 2. The difference in the percentage breakdowns in each group of trucks for fixed and variable costs may be explained by the variations in mileage travelled by each group. In the aggregate, including all trucks, 59.4 percent of the total miles were employed in the service of hauling grain. The other 40.6 percent of the total miles were involved in other services such as general freight, livestock, coal and gravel, etc.

Stratification of Costs by Size of Truck

The characteristics of the various groups of trucks, stratified according to size, yielded cost figures which are shown in the following table.

Table 2. Comparison of Assembly Costs for Different Sizes of Trucks in the Study

Truck Size	Number in Sample	Average Load Size	Average Distance of Haul	Average Cost per Bushel-Mile
1 and 2 tons	8	180 bus.	18.43 miles	.4859 cents
3 tons	32	303 bus.	19.74 miles	.2609 cents
4 and 5 tons	5	450 bus.	40.24 miles	.1297 cents
all	45	300 bus.	21.78 miles	.2857 cents

It was hypothesized that the size of the truck and the average load size, would have an inverse effect on the cost. As can be seen from Table 2, the model confirms this hypothesis.

The range of the distribution of costs for individual trucks is from a low of .0699 cents per bushel-mile to a high of .9400 cents per bushel-mile. The average cost for all sizes of trucks is .2857 cents per bushel-mile. The largest number of vehicles have cost figures which are lower than the average cost. However, there are a few vehicles with excessively high costs, because they are under-utilized. This emphasizes the fact that trucks must operate near capacity to render economic service. It also illustrates that if commercial trucks or larger custom farm trucks were used to a greater extent, further economies may be enjoyed.

Stratification of Trucking Costs Based on Size, Age, and Total Mileage on the Trucks

It was hypothesized that the costs of hauling grain commercially would depend on size and age of the truck. The following table shows the costs of one and two ton trucks as a function of total truck miles, age of truck, load size, and one-way loaded miles.

It was hoped that this information would help to show what effect the total miles travelled by trucks has on their costs of operation. However, because of the limited number of trucks in this group, it is very difficult to determine just what effect the total mileage has on the costs incurred by trucks. In the one and two ton group, there were indications that the older trucks on the average are slightly more expensive to operate. Table 4 displays this observation on the basis of average cost, by total miles for the year.

Table 3. The Average Trucking Costs for One and Two Ton Trucks Based on the Total Miles on the Trucks

Total Truck Miles (since new)	Age[a]	Year	Average Load (bus.)	Mileage (Average One-Way Loaded)	Cost (cents per bushel-mile)
less than 30,000	1963-	1968	200	14.19	.4989
30,001 to 75,000	1956+	1951	145	14.79	.6574
30,001 to 75,000	1963-	1964	150	11.52	.2423
75,001 and over	1956+	1951	225	31.90	.4028

[a]For the truck age, a minus sign indicates the year designated and newer than. The plus means the year designated and older than.

Table 4. The Average Trucking Costs for One and Two Ton Trucks Based on the Total Yearly Miles on the Trucks

Total Yearly Miles (1967-68)	Age[a]	Year	Average Load (bus.)	Mileage (Average One-Way Loaded)	Cost (cents per bushel-mile)
less than 2,000	1956+	1951	145	14.79	.6574
less than 2,000	1963-	1967	200	23.53	.7139
2,001 to 5,000	1956+	1951	225	31.90	.4028
5,001 to 8,000	1963-	1966	175	11.85	.2850
8,001 to 10,000	1963-	1968	150	6.87	.4551

[a]For the truck age, a minus sign indicates the year designated and newer than. The plus sign means the year designated and older than.

A similar analysis was completed for the three ton trucks. It was found, as hypothesized, that the three ton trucks operated at a lower average cost per bushel-mile than the one and two ton trucks; the four and five ton trucks were lower in average cost per bushel-mile than the three tons. Thus, as was expected, there are economies to be obtained from using larger trucks.

Table 5. The Average Trucking Costs for Three Ton Trucks Based on the Total Miles on the Trucks

Total Truck Miles (since new)	Age[a]	Year	Average Load (bus.)	Mileage (Average One-Way Loaded)	Cost (cents per bushel-mile)
less than 30,000	1956+	1953	242	14.15	.4077
less than 30,000	1957-62	1960	300	8.40	.3460
less than 30,000	1963-	1967	287.5	12.70	.4530
30,001 to 75,000	1956+	1952	288	21.55	.1503
30,001 to 75,000	1957-62	1961	325	21.00	.4317
30,001 to 75,000	1963-	1965	329	21.03	.1901
75,001 and over	1956+	1955	300	14.60	.2410
75,001 and over	1957-62	1960	294	21.92	.2178
75,001 and over	1963-	1964	350	34.50	.1566

[a]For the truck age, a minus sign indicates the year designated and newer than. The plus sign means the year designated and older than.

Table 6. The Average Trucking Costs for Three Ton Trucks Based on the Total Yearly Miles on the Trucks

Total Yearly Miles (1967-68)	Age[a]	Year	Average Load (bus.)	Mileage (Average One-Way Loaded)	Cost (cents per bushel-mile)
2,000	1956+	1952	292	10.85	.3346
2,000	1957-62	1961	300	12.45	.5100
2,000	1963-	1967	300	7.31	.9400
2,001 to 5,000	1956+	1954	275	18.25	.2461
2,001 to 5,000	1957-62	1959	335	17.24	.3299
2,001 to 5,000	1963-	1965	250	3.50	.3372
5,001 to 8,000	1956+	1951	250	25.00	.3552
5,001 to 8,000	1957-62	1959	300	7.10	.2474
5,001 to 8,000	1963-	1966	333	29.04	.1890
8,001 to 10,000	1957-62	1960	287.5	29.24	.1155
8,001 to 10,000	1963-	1964	310	15.22	.1655
10,001 to 20,000	1957-62	1960	302	22.94	.1795
10,001 to 20,000	1963-	1964	325	25.49	.2370
20,000	1963-	1967	350	23.48	.1521

[a]For the truck age, a minus sign indicates the year designated and newer than. The plus sign means the year designated and older than.

In the average costs shown in Table 6, there seems to be some indication that in the three ton size group the optimum vehicles to use, as far as age is concerned, are those in the range from five to ten years old. This may be explained by the fact that trucks in this age group have a lower fixed cost assessment, and the variable costs incurred such as repairs, have not at this point increased substantially over the newer vehicles. Once trucks exceed ten years of age, considerably more expense is required in repairs to keep them in service. When trucks are new, insurance and depreciation especially, are considerably higher cost factors.

Table 7. The Average Trucking Costs for Four and Five Ton Trucks Based on the Total Miles on the Trucks

Total Truck Miles (since new)	Age[a]	Year	Average Load (bus.)	Mileage (Average One-Way Loaded)	Cost (cents per bushel-mile)
30,001 to 75,000	1963-	1966	450	53.88	.1614
75,001 and over	1956+	1953	400	47.90	.1031
75,001 and over	1963-	1966	425	45.54	.1014

[a]For the truck age, a minus sign indicates the year designated and newer than. The plus sign indicates the year designated and older than.

The information in Table 7 and Table 8 indicates the possible cost advantages of utilizing larger trucks. Also, it can be observed by comparing the above table with the similar tables for one and two tons, and three tons that the average distance hauled by these trucks is much greater than the others.

Observe the last row of Table 7 for 1963 or newer trucks, across from greater than 75,001 total truck miles. The average cost is .1014 cents per bushel-mile. That means approximately $20 to haul 425 bushels a distance of 45.5 miles, or less than 5 cents a bushel. This particular case has a lower average cost than will be found in general, but it does indicate that economies of scale do exist in the industry.

Table 8. The Average Trucking Costs for Four and Five Ton Trucks Based on the Total Yearly Miles on the Trucks

Total Yearly Miles (1967-68)	Age[a]	Year	Average Load (bus.)	Mileage (Average One-Way Loaded)	Cost (cents per bushel-mile)
8,001 to 10,000	1963-	1964	400	20.23	.2182
10,001 to 20,000	1956+	1953	400	47.90	.1031
10,001 to 20,000	1963-	1967	400	17.59	.1002
20,001 and over	1963-	1967	475	57.40	.1136

[a]For the truck age, a minus sign indicates the year designated and newer than. The plus sign indicates the year designated and older than.

The Average Speed of the Various Sizes of Trucks

The results as taken from the data indicated that there are differences in the average speed travelled by the various sizes of trucks. As well as speed, the loading, unloading, and waiting time are also slightly varied for the different size groupings. The following table shows the calculated average speeds for the various sizes of vehicles, and dead haul time; this information would be most important in determining optimum distance between elevators.

Table 9. The Speed and Dead Haul Time of the Various Sizes of Trucks

Truck Size	Dead Haul Time Two-Way	Speed
1 and 2 tons	49.3 min.	31.9 mph.
3 tons	41.0 min.	34.0 mph.
4 and 5 tons	43.3 min.	45.8 mph.

Results of Regression Analysis

After running a regression analysis with the model developed in Chapter II, it was found that the earth and gravel miles, as separate variables, were not statistically significant. However, there was a high degree of correlation between the two, and for this reason, it was decided to combine earth and gravel miles as one variable.

The new functional model after adjustment looked as follows:

$$Y = f(X_1, X_2, X_3, X_4, X_7, X_8, X_9, X_{10}, X_{11}).$$

A definition of the variables can be found on Page 32. The new variable X_9 was inserted to account for the percentage of miles travelled on earth and gravel and thus to replace variables X_5 and X_6. An individual regression was run on each variable. The results of this procedure allowed the variables to be set up in an order related to their R^2 value. This was done as a matter of mechanics to show the significance of each independent variable in relation to the others. The ordering of variables in the functional model then looked as follows:

$$Y = f(X_2, X_4, X_1, X_3, X_8, X_9, X_7, X_{10}, X_{11},),$$

with the variables with the highest R^2 values at the left.

To test the appropriate form of the model, both linear and Cobb-Douglas equations were used. The linear regression analysis yielded an R^2 of .531 while the Cobb-Douglas regression analysis gave an R^2 of .665. This may be interpreted to mean that 66.5 percent of the costs, Y, were explained by the variables in the model. In the study by Butler[1], a curvilinear relationship was also found to give a better fit than linear in truck costing analysis. The final curvilinear model of the independent variables and the dependent cost variable, was set up as follows:

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[1] A. H. Butler, "A Cost Analysis of Transferring Grain by Farmer Owned and Operated Trucks", (Unpublished Master of Science Thesis, University of Manitoba, Winnipeg, October, 1970).

$$Y = aX_2^{b_2} X_4^{b_4} X_1^{b_1} X_3^{b_3} X_8^{b_8} X_9^{b_9} X_7^{b_7} X_{10}^{b_{10}} X_{11}^{b_{11}}$$

Here "a" is the constant, and the X values are the designated independent variables, and the b coefficients are the elasticities of each independent variable as they affect the cost of hauling grain per bushel-mile. The elasticity is the amount of change in the dependent variable caused by a given change in the independent variable.

There was correlation between many of the variables which would likely affect the results. Some of the variables such as X_1, the size of the truck, and X_4, the load size in bushels, would be related to a large enough degree that each would be creating a similar effect on Y. As the truck size is increased, it can be assumed that the size of load could also be increased. On this grounds, the two variables could have a similar effect on Y. The correlation coefficients between all the variables studied are shown in the following table.

Table 10. Correlation Coefficients of the Variables of the Model

	Y	X_2	X_4	X_1	X_3	X_8	X_9	X_7	X_{10}	X_{11}
Y	1.00									
X_2	-0.59	1.00								
X_4	-0.56	0.46	1.00							
X_1	-0.49	0.38	0.87	1.00						
X_3	-0.48	0.27	0.37	0.26	1.00					
X_8	-0.32	0.57	0.61	0.58	0.15	1.00				
X_9	-0.23	0.02	0.36	0.13	0.12	0.07	1.00			
X_7	0.03	-0.36	-0.15	0.07	-0.03	-0.17	-0.04	1.00		
X_{10}	-0.37	0.62	0.48	0.48	0.39	-0.72	-0.02	-0.09	1.00	
X_{11}	0.21	-0.23	0.13	0.21	0.28	0.43	-0.00	0.27	0.35	1.00

In order to examine the effect of the independent variables on the dependent variable, a step by step regression was used. This procedure allowed for a special look at the model, by bringing in one variable at a time. For example the program would analyze both the linear and Cobb-Douglas equation for $Y = f(X_2)$, then it would analyze $Y = f(X_2, X_4)$, and so on until all the variables were included.

The object of this type of analysis is an attempt to find those variables which have the greatest effect on grain hauling costs. There were three variables statistically significant at the five percent level. These variables were: X_3 (the one-way haul), X_7 (the age of the truck), and X_{11} (the proportion of miles hauling grain). However, because of the correlation that occurred between the variables in the model, the effects of one variable could be partly accounted for by another. For example, variable X_1 (the size of truck) and variable X_4 (load size), had a correlation coefficient of 0.87.

Another aspect to consider is the 95 percent confidence limit. Because 95 percent was chosen for this study does not mean that it is required to achieve satisfactory results. The nature of the trucking industry and its cost factors may only demand 80 percent confidence to arrive at a satisfactory result. If such a case is justifiable, two more independent variables could be significant. These variables are:

1. total yearly miles travelled
2. total yearly volume of grain.

The model substantiated the earlier hypothesized inverse and direct relationships between the independent variables and the dependent variable with the exception of one. The exception was variable X_9 (percent of earth and gravel miles). The statistical value for t at 95 percent confidence is 2.26, the calculated value of t for variable X_9 was -0.92.

In order that the model be used to estimate, it would be necessary to determine the magnitude of each independent variable. Then these variables could be placed in the model and the predicted cost of hauling grain per bushel-mile determined. The value of the model, is very limited, when we have to assume all the variable relationships hold. For example, using the Cobb-Douglas equation we could show that: $Y = \log a + b_1 \log(X_1)$. In this case, if Y were only dependent on X_1 we could determine Y_1, once the value of X_1 was determined. To estimate the value of Y, it becomes necessary to have an estimated X_1 value. In short, once a value of the independent variable is estimated, the value of the dependent variable can be determined, based on the new found value of the independent variable.

The regression analysis completed in this study yielded results that allowed for the comparison of actual costs, and predicted costs of hauling grain. Also the calculated regression coefficients made it possible to use the model in estimating the costs of hauling grain. The following tables yield this information as tabulated from the analysis.

Table 11. Test of Difference Between One-Half Cent and Average Transportation Costs per Bushel-Mile for Different Sizes of Trucks

Size of Truck	Number of Trucks	Mean of Sample	Variance of Sample	Std. Dev.	Calc. "t"	Theor. "t" 5%[a]	Test
all	45	.29	.44	.22	-6.71	2.31	reject
1 and 2 tons	8	.49	.38	.19	-0.02	2.36	accept
3 tons	32	.26	.40	.20	-6.73	2.03	reject
4 and 5 tons	5	.13	.40	.20	-4.17	2.78	reject

[a]one tailed test

Table 12. Comparison of Actual and Predicted Transportation Costs for Different Sizes of Trucks

Size of Truck	Number in Sample	Actual Average Cost per Bushel-Mile	Predicted Average Cost per Bushel-Mile	Difference
all	45	.29	.27	-0.02
1 and 2 tons	8	.49	.47	-0.02
3 tons	32	.26	.24	-0.02
4 and 5 tons	5	.13	.13	-0.00

Table 13. Regression Estimates of Trucking Cost Relationships for the Cobb-Douglas Equation

Variables	All Trucks Regression Coefficients[a]	Standard Error
Constant	.2733	
X_1	-.3218	.4795
X_2	$-.1621^{++}$	.1391
X_3	$-.4497^{+}$	.1278
X_4	-.1176	.5542
X_7	$-.1451^{+}$	.0699
X_8	$-.1637^{++}$	.1256
X_9	-.0767	.0825
X_{10}	+.0368	.1025
X_{11}	$+.3481^{+}$	.1244
R^2	.6650	

[a]A single plus superscript indicates the regression coefficient is statistically significant at the 5 percent level; a two plus superscript indicates significance at the 20 percent level.

Present Commercial Trucking Rates

Commercial truckers, in the summer of 1969 and for the period of this study, were charging rates generally below the trucking costs suggested by earlier research, (.5 cents per bushel-mile). The following rates are the average being charged by commercial truckers for grain hauling in the block area studied.

Table 14. Commercial Truckers' Rates for Hauling Wheat and Barley Various Distances in Cents per Bushel

0 to 5 miles	6 to 10 miles	11 to 15 miles	16 to 25 miles	26 to 50 miles	51 to 75 miles	100 miles
2.68	3.66	4.72	6.36	9.42	12.20	17.83

Table 15. Commercial Truckers' Rates for Hauling Oats Various Distances in Cents per Bushel

0 to 5 miles	6 to 10 miles	11 to 15 miles	16 to 25 miles	26 to 50 miles	51 to 75 miles	100 miles
2.39	3.47	4.03	5.40	6.95	9.90	16.28

For the 16 to 25 mile category, the calculated average total cost of grain hauling is 6.0 cents per bushel, compared to 6.36 cents presently being charged by the truckers. With the rates being charged by commercial truckers comparing closely to the findings of this study, and with the new calculated farm trucking costs determined by Butler (.33 cents per bushel-mile), it seems apparent that grain trucking costs are below the .5 cents per bushel-mile.

CHAPTER IV

CONCLUSIONS AND IMPLICATIONS

Brief Background to Conclusions

This study indicates that if it is costing grain producers one-half cent per bushel-mile to haul grain by their own truck, they are paying more than necessary. Butler, in his study indicates that the average cost of hauling grain by farm truck is not one-half cent per bushel-mile, but rather .3396 cents per bushel-mile.[1] Butler's sample was composed of a larger portion of smaller trucks, while this study sample had a larger number of large trucks. The calculated average cost of operating commercial trucks for the purpose of hauling grain is .2857 cents per bushel-mile. The vehicles tested in the sample ranged in size from one ton to five tons. Both Butler's study and this one show that there are definite advantages to be had by considering economies of scale and employing larger vehicles. There may be further economies to gain by using commercial vehicles, provided more producers are willing to patronize the industry. By increasing substantially the volume of grain moved by commercial vehicles, larger units should be able to operate more efficiently. Allowing such events to develop could reduce the present average cost of moving grain.

Suggesting that larger trucks haul a greater portion of grain to country elevators creates many sociological and political problems. One of the first questions asked by producers will be, "Does that mean we will have to haul greater distances to elevators, and if so, what happens to

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[1] A. H. Butler, "A Cost Analysis of Transferring Grain by Farmer Owned and Operated Trucks", (Unpublished Master of Science Thesis, University of Manitoba, Winnipeg, October, 1970).

our communities?" These are difficult sociological problems which will have to be decided by the politicians. In an economic framework, it is feasible in the long-run to plan an elevator system, locating elevators farther apart. This implies increasing the average distance producers will have to haul grain. Provided commercial or larger farm trucks are made available to haul the grain the longer distances, and provided that storage and handling costs are reduced by having fewer elevators, the economies in hauling grain longer distances becomes feasible. It also implies a change in producer philosophy with regards to his community and elevator points. Whether producers are willing to accept such a proposal is another matter, but this research has shown that cost advantages can be achieved by greater utilization of larger vehicles for the purpose of hauling grain from farms to country elevators.

Conclusions

The study, in its calculations supported the hypothesis that costs of hauling grain are inversely related to the size of the truck. The average cost by size of truck indicates that one and two ton trucks are the most expensive, followed by three tons and then the four and five tons which have the lowest average cost per bushel-mile. Statistically, the size of the truck did not prove significant as a cost determining variable, however, the broad range of costs for the three tons as illustrated earlier, could have a decisive effect on the results of the statistical analysis.

The study also supports the hypothesis that on the average, the cost of operating a vehicle is reduced when the number of loaded miles is increased. Also the load size is important. The greater the average size of load, the lower will be the average cost per bushel-mile.

Because most of the vehicles in the sample travelled various proportions of their mileages on different types of road surfaces, it was not possible to isolate what cost effect road surface has on the cost of hauling grain. However, it has been pointed out by other studies[2] that road surface does affect costs for items such as tires and repairs.

Because truckers travelled varying distances under load and because the load mileage varied, it was difficult to assess what effect total truck mileage had on average cost. If it is assumed that total miles on a truck are dependent on the age (i.e., the older the truck the more miles it has travelled), it would be safe to state that mileage on a truck would have a negative effect with respect to average cost.

The single most important finding of the study is that the average cost of hauling grain by commercial trucks ranges from .0699 to .9400 cents per bushel-mile with the average cost at .2857 cents per bushel-mile.

Excess Trucking Capacity

When talking with farmers and truckers when taking the survey, it was evident that many of them would be interested in hauling more grain commercially. The problem, they pointed out was the fact that there is not enough volume of grain to be moved by commercial trucks to make a viable business. Farmers who presently haul grain for neighbours as a supplementary sideline to the farm business, maintain that considerably more volume could be moved with their vehicles. The conclusion may be drawn from this information that there appears to be a great deal of excess capacity in the industry. Although the excess capacity would be

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[2] Gardewine and Sons Limited, The Submission to the Royal Commission on Northern Transportation, (Winnipeg, April, 1968), p. 13.

difficult to measure, the fact that some of the trucks only travel 2,000 miles annually seems to further substantiate the argument of excess capacity.

Distance Travelled Hauling Grain

The average distance hauling grain by commercial trucks is greater than the average distance hauling grain by farm truck. This claim is made based on a comparison of this study and a study completed by Butler on the cost of moving grain by farm trucks. The average distance travelled by farm trucks in the process of hauling grain from farms to country elevators is 6.27 miles.[3] The average distance hauling grain by commercial trucks is 21.78 miles according to the data used in this study. There are several explanations for the average differences between the farm vehicles and those of the commercial trucks. First, in some cases farmers do not maintain a type of truck that would stand up mechanically to the longer hauling distances; second, some farmers in the outlying areas utilize a tractor and wagon to place grain in farm storage - the purchase of a truck for the purpose of hauling grain to the elevator point would be a poor investment, as long as custom hauling rates are as reasonable as they are at the present; third, many of the grain farmers own smaller trucks and according to this study, smaller trucks have higher costs per bushel. It must be remembered that many of the custom truckers in this survey were farmers. The reduced cost for these farm vehicles is created by the extra utilization of the trucks doing custom work. In short, if a truck is purchased by a farmer to haul grain, he should employ it fully in order that it be an economic investment.

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[3]Butler, op. cit.

Marginal Costs to Producers to Travel the Extra Miles by Commercial Trucks

Information regarding grain trucking costs should be concern to individual producers. Any increase in distance from the farm to the country elevator implies an increase in the cost of hauling grain to the producer. The calculations in Table 14, Chapter III confirm this to be the case. However, it should be kept in mind that an actual cost reduction may be achieved in the aggregate if the producer concerned changes his mode of transportation, (i.e., from his own truck to employment of a larger vehicle which operates at less cost). Of course it will not always be practical to change modes, as many producers will require a truck for purposes other than the hauling of grain to country elevators. For producers employing commercial vehicles, the actual costs incurred by the trucker to travel the extra miles will be illustrated with three examples. The calculations are made on the basis of the data from this research project.

Case I: In this case, a trucker uses a one or two ton truck. The average load size is 180 bushels. In this case, the estimated marginal costs per bushel-mile are .2177 cents. The .2177 is arrived at by summing all the variable costs minus the dead freight cost. Therefore, the cost per extra mile of travel under load would be 180 (.2177) = 39.18 cents. This cost includes: tires and batteries, lubrication, fuel, hired maintenance labour, personal maintenance labour, personal driving labour, hired driving labour, and repairs.

Case II: Similar cost variables were used to those in Case I. The truck size was three ton and the load size was an average of 303.4 bushels. The marginal costs measured per bushel-mile are .1236 cents. Therefore, the cost per extra mile of travel under load would be .1236 (303.4) = 37.5 cents.

Case III: Similar to the previous two cases, the four and five ton trucks were assessed marginal costs per loaded mile. The calculated cost on a bushel-mile basis is .0836 cents. The cost per extra mile under average load of 450 bushels would be 450 (.0836) = 37.6 cents.

After observing the results of the above three cases, it could be concluded that approximately 38 cents per additional mile would be a reasonable marginal cost figure for custom trucks in the process of hauling grain. The over-all change in the actual average costs to individual producers will depend on, first; the method they were using (i.e., their own or a commercial vehicle), second; how much farther the producer would be required to haul under a new rationalized rail and elevator grain handling system.

Implications for Custom Truckers and Producers

The model developed in this study should determine the costs to be incurred in a prospective grain trucking business venture. The model is developed in Chapter II. The limitations of the model are determined by:

1. The relationships between the dependent and independent variables staying the same; i.e., the regression coefficients remain unchanged.

2. The price of variable inputs remaining constant. Should input prices change, the amount of variation should be measured and the variables adjusted accordingly. This means the regression analysis should be rerun to determine new b values.

3. The accuracy of the potential business submitted by the trucking entrepreneur to be analyzed.

The following procedure is a hypothetical case to explain the mechanisms required to determine the costs in cents per bushel to haul grain varying distances. The results are determined using the calculated regression coefficients determined by the model.

Suppose an individual Mr. M. is considering operating a custom grain trucking business. After examining carefully the business potential, it is determined that the factors which affect his future in the business look as follows.

X_2	= 20,000 miles	(total yearly)
X_4	= 300 bushels	(average load size)
X_1	= 3 ton	(size of truck)
X_3	= 20 miles	(average haul loaded)
X_8	= 200,000 bushels	(yearly volume)
X_9	= 50 percent	(miles of earth and gravel)
X_7	= new truck	(age of truck)
X_{10}	= $3,000	(minimum return to labour)
X_{11}	= 100 percent	(proportion of business hauling grain)

Table 16. The Cost of Hauling Grain Various Average Distances as Determined by the Model for the Proposal of Mr. M.

Average Hauling Distance	Costs in Cents per Bushel-Mile	Total Cost	Costs in Cents per Bushel
10 mile average	.3060	$ 9.18	3.1
20 mile average	.2245	13.47	4.4
30 mile average	.1870	16.83	5.61
40 mile average	.1644	19.72	6.57
50 mile average	.1486	22.29	7.4

Implications to the Railways

If commercial trucks or custom trucks were employed to move grain longer distances from farms to country elevators, the railroads as a vital link in the grain transportation network could experience tremendous structural changes on the prairies. Under present federal legislation, only unprotected lines can be considered for abandonment by the Canadian Transport Commission until 1975. At that time, if a long-run abandonment program is put into effect, greater efficiency could be achieved from the service.

Reduced numbers of rail lines and elevator points would create greater centralization for the railway companies. Instead of servicing some rail lines once a week, as is presently done in some areas, it would allow for more frequent grain car services on fewer heavy traffic lines. Under the more centralized conditions, railways would be able to utilize their boxcars to greater advantages. Although it may be premature to suggest that unit trains could operate in the near future in the grain industry, reduced trackages would allow for speedier car turnover and directly reduce the number of boxcars required to move a given amount of grain. This would mean that railways should be able to reduce high capital expenditures on the maintenance and construction of boxcars.

The average return period for boxcars loaded with grain to Thunder Bay has been 13 to 14 days in the past, providing unloads at seaboard ports were not hindered. Under the new Canadian Wheat Board block system it has been suggested that the car return will be reduced to 10 days. It can be suggested that boxcar turnover time be further reduced if the railroads are permitted to operate on a lower number of high density lines. The formation of a grain train going to the east or west ports could be a faster operation if the boxcars making up the train come from one or perhaps two lines. It is not the intent of the author to suggest that one or two lines are all that are required to service the prairies; on the contrary, perhaps two or three times this many are required. Further, the railways would be able to save considerable expenditures on the upkeep of low density lines if they are allowed to abandon them. However, at the present time, the railways are operating under a Federal Government subsidy program which will be up for review in 1975. Perhaps before that date, considerations of the alternatives should be completed. If government subsidy is to continue as a long-run solution, the efficiency of grain transportation may be held considerably below what could be attained.

Present Prairie Railway Track Service

At the present time, the C.N.R. and the C.P.R. maintain 18,982 miles of track on the prairies, exclusive of sidings and passing service sidelines. The mileage is distributed throughout the three provinces in the following manner: Manitoba 4,735, Saskatchewan 8,567, and Alberta 5,680. On this 18,982 miles of track, there are 1,908 individual elevator points. (An elevator point consists of one or more elevators.) There are 333 elevator points in Manitoba, 1,037 elevator points in Saskatchewan, and 538 in Alberta.

By utilizing the above information and observing the structural network of the present rail facilities on the prairies, the following brief analysis raises some interesting implications. A map of the prairies was examined to determine the number of east-west rail lines at several longitudinal degree points. Two basic assumptions were made. The first assumption was that farms are randomly distributed throughout the prairies; the second was that grain flow patterns are randomly distributed throughout the prairies.

The first observation of rail line locations was made at 101 degrees longitude on the Canadian Prairies, from township 21 to the U.S. border. The distance covered is 126 miles. In this range of miles, there are ten lines passing through in an east-west plane, not including numerous spurs or branches from these lines, and not including lines that run in a north-south direction in the immediate vicinity. This means that the average distance between railway lines is 12.6 miles, (126 divided by 10). A further calculation shows that farmers in this area have an average distance of 3.15 miles to rail lines. The average distance of 3.15 miles to rail lines by no means indicates how far a producer must haul to an elevator, because elevators are not located in a continuous string along the track. Rather, in Manitoba it is found that elevator points are an average distance of 14.2 miles apart along rail lines, (4,735 track miles divided by the 333 elevator points). By utilizing the average distance farmers travel to rail lines and the average distance between elevator points along the rail lines, it was determined that the average distance at 101 degrees longitude, for farmers to haul to elevator points is 7.76 miles. Diagrammatically, this can be illustrated as follows:

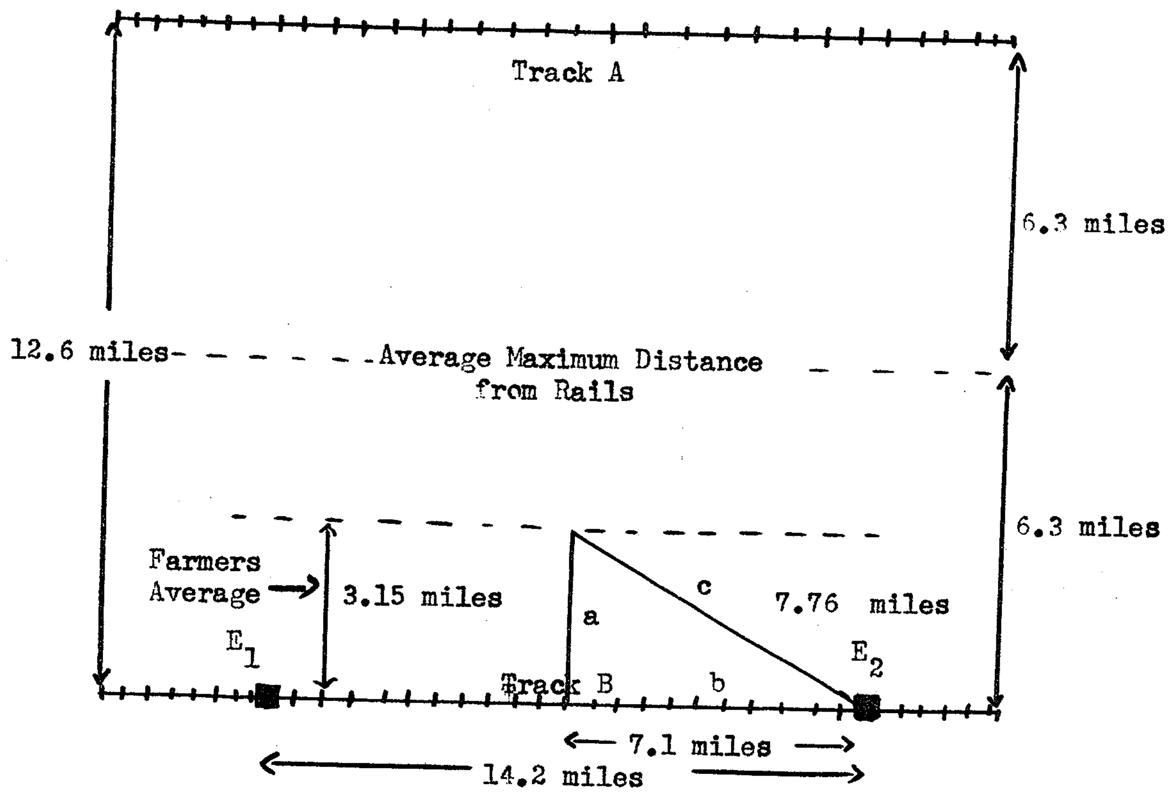

Figure 6

Average Distance Farmers Haul to Elevator Points Based on the Average Mileage from Producers to Rail Lines, and the Average Distance between Elevators on Rail Lines for the Six Designated Areas

Track A and Track B are 12.6 miles apart. The farthest distance any producer is from the track, based on the average information, would be 6.3 miles. Thus the average distance is 3.15 miles. The elevator points are an average of 14.2 miles apart, as indicated by E_1 and E_2. Therefore, the average distance of haul for farmers is c, calculated from: $a^2 + b^2 = c^2$. In this case, the resulting average mileage for producers was 7.76 miles. It should be re-emphasized that this calculation did not consider all spur rail lines that are located in this area. Also, no consideration was made for geographical barriers such as rivers and creeks, or bad road conditions. However, five similar calculations were made: one for Manitoba, and two each for Saskatchewan and Alberta. The results are shown in the following table.

Table 17. Estimated Average Distance Farmers Haul to Country Elevators

Province	Degrees Longitude	Number of East-West Rail Lines	Range in Miles North to South	Average Miles Between Rail Lines	Average Distance Farmers Haul[a]
Manitoba	101	10	126	12.6	7.76
Manitoba	100	12	108	9.0	7.46
Saskatchewan	104	18	300	16.7	5.94
Saskatchewan	106.5	15	300	20.0	6.53
Alberta	110	13	294	22.6	7.60
Alberta	113.5	14	312	22.3	7.50

[a]This is based on the fact that in Saskatchewan the average distance between elevator points along rail lines is 8.43 miles, and in Alberta it is 10.45 miles. These figures were used in the calculation of the average distance of farmers' haul in the above table.

The average of the six areas was calculated to be 7.13 miles. If north-south lines and all spur lines had been considered, the average would be slightly reduced. This brief analysis appears to support the 6.27 mile average haul calculated by Butler in his research.[4] The most important implication to the railways is the fact that many low density traffic lines are being maintained at present. The cost of such maintenance may far exceed the revenues to the railways. The present goverment program to subsidize the railways in order to maintain non-paying lines, may not be in the best long-run interests of producers or an efficient

[4]Butler, op. cit.

grain transportation system. This suggestion is made with the knowledge that commercial trucks can be utilized efficiently over longer distances than is presently the case.

Another aspect of this study is to apply economic theory to the comparison of rail and truck services in the movement of grain. In western Canada at the present time, grain producers are trucking grain an average of 6.27 miles to country elevators.[5] It may be possible that the farmer could reduce his over-all cost of grain movement by hauling a greater distance via commercial truck, and having fewer elevators at which to deliver. The following model should help explain the theoretical aspects of this possibility.

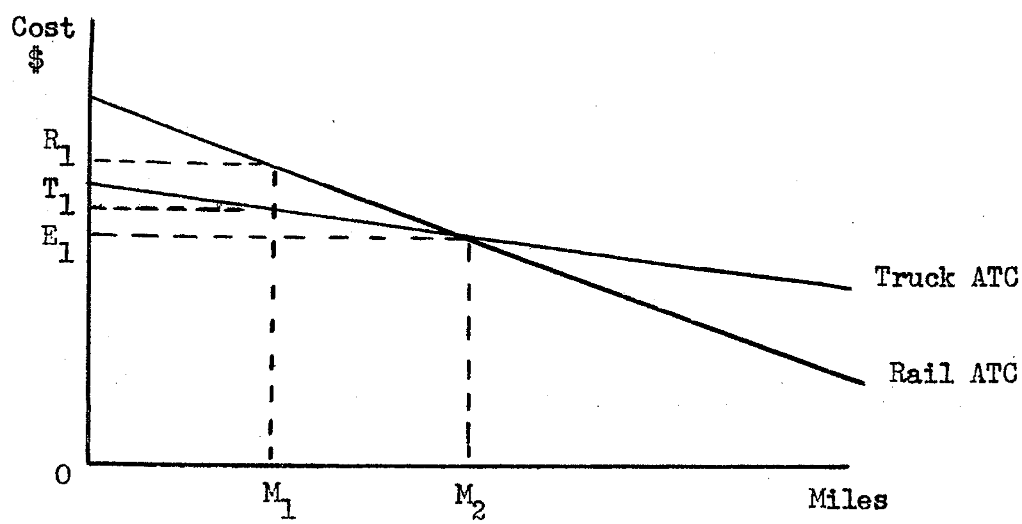

Figure 7

Hypothetical Model Showing the Efficient Distances for Hauling Via Rail Versus Truck

[5]Butler, op. cit.

Assume that the system is operating at M_1 miles. To haul M_1 miles means that the farmer is paying, via truck, a transfer cost of OT_1. If a producer had a railway accommodate him at a similar hauling distance, the cost incurred would be OR_1. Now suppose that the average distance of grain haul is increased to M_2. At the distance M_2 miles, the AC associated with rail and truck movement of grain are the same, i.e., they are both OE_1. It can be seen from the diagram that throughout the distance M_1 up to M_2, the costs associated with trucking are below that of rail. Therefore, to achieve optimum use of a transportation network the trucks should be utilized to mileage M_2, beyond this point the railway holds cost advantages.

To further elaborate on the length of the haul by road and rail, here is what A. W. Currie pointed out.

> In 1926, there was coming to be a fairly well defined body of opinion that in general, the economical range of motor truck operation does not exceed 50 or 60 miles. Some who, for various reasons, are advocating the use of motor trucks, place their limit considerably higher than this figure, even specifying 125 or 150 as economically possible. On the contrary, railway officials and many others who are conservative in their statements, would place the limit of this short-haul movement at 25 miles.[6]

In recent years, trucks have shown exceedingly improved gains in volume movement and distance travelled. The Gordon Commission in 1956, suggested that the greatest concentration of intercity motor truck activity is on routes between 20 and 600 miles in length. A great volume of motor carrier traffic also moves on routes up to 1,500 miles in length; but beyond that point there is considerable doubt as to whether or not line-haul motor carrier operations are profitable or practical.

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[6] A. W. Currie, Canadian Transportation Economics, (University of Toronto Press, Toronto, 1967), p. 149.

It is not to be suggested here that we consider movement of grain as far as 1,500 miles by truck. However, it should be pointed out that transportation efficiencies may be lost because of a failure on our part to rationalize the systems available to us. In Canada at the present time, the producer is subsidized indirectly by the "Crows Nest Rate" which holds the real rail rates down and distorts the picture of actual rail freight costs. However, let it be clear that economies may be achieved both in rail costs and trucking costs, if there are fewer rail lines and reduced numbers of elevators. It appears from the cost figures of this study that actual cost per mile of haul via larger trucks could be substantially reduced if producers were faced with a new spatial relationship of railways and country elevators.

Implications to the Country Elevator System

The hauling of grain longer distances by commercial trucks, may allow for the removal of many railway lines. Immediately this creates problems for the grain elevator companies. Large amounts of capital are invested in the country elevator buildings. In the past ten years, grain companies have been concerned over the fate of many of the branch rail lines. In general, very little new construction has taken place on any line that has a questionable future. In a long-term rail line rationalization program, serious consideration must be given to the elevator companies' position. It may be desirous to have a minimum loss of elevator assets, by removal of lines where the plants have been mostly depreciated out, wherever possible. The rail line abandonment program should clearly be spelled out long in advance of implementation, so that grain companies are able to create for themselves a position of minimum capital loss. It may be thought that an elevator depreciated to a book value of zero, is really not a loss. However, the serviceability of the house may be quite efficient and replacement of such facilities at a new point would be costly.

There is evidence that we may not require the number of elevators that are operating, to effectively service the industry. The handling to capacity ratio for Canada's licensed grain elevators, according to the Board of Grain Commissioners, was 1.56 in the 1967-68 crop year. Facilities that are presently constructed have the capacity to handle at least three times that amount without any serious strain on the system. What is being suggested is that prairie grain for domestic and export requirements, could be handled with elevators that are already constructed. In a long-run plan, the older elevator plants could be phased out of the system at low cost, and the remaining plants could handle the grain required for export and local needs, with little or no new construction.

Implications to the Canadian Wheat Board Block Shipping System

The recent development of the block shipping system by the Canadian Wheat Board is a program innovation to improve the movement of grain from country elevators to terminal positions. The types and grades of grain called forward by the Board to meet sales commitments must be adhered to by elevator agents in their shipping program. The control of the type of shipments going into the grain network will prevent serious bottlenecks, as was experienced in the winter of 1968-69 at Vancouver. Further, a more rapid turnover of boxcars can be expected, because of the fact that cars loaded with grain will be of an immediate saleable nature. Boxcar tie-ups at unload should be prevented, (i.e., cars should not have to be weeks in transit), as they will be unloaded within a short time of arrival at the terminals.

The fact that larger trucks move grain over longer distances more efficiently, may provide the Board with a mechanism to allow farmers to haul to alternate points within a block or ultimately to any point in the block that has space available. This possibility raises some interesting points.

1. As railways have varying degrees of traffic on different rail lines, it will become more economical for them to supply boxcars to points on higher density lines. Thus the space made available at such points increases. Under these conditions, producers' grain would begin to move in the direction of the larger turnover points. In the long-run, the elevators on the lighter traffic lines will be providing less and less service, ultimately they will become too inefficient to maintain, and will be retired.

2. A reduction in the number of elevators would give the Canadian Wheat Board more direct and efficient control over grain movements. Allocations of boxcars would be to fewer elevator points and in larger numbers. This could mean a faster turnover of boxcars and a more rapid movement from the prairie points.

3. If trucks haul to fewer points under the block shipping system, it does not necessarily mean that total deliveries will be reduced because of a reduction in storage capacity. Once elevators are full, they serve no valuable purpose other than the warehousing of grain. If the elevator is full at harvest time, it means that producers have to provide storage for their entire crop on the farm. Until the elevator begins to ship grain to internal processing or export positions, it can not provide any grain handling service to the producer. If additional storage is built

onto the elevator, it is only a temporary relief and not a long-run solution to the marketing of grain.

In the past few years many farmers have been storing all or most of their entire crop. Building storage annexes to increase elevator capacities above what is presently available, by and large only transfers the storage from the farm to the track sites. It does not alleviate our grain surplus. In fact, if sales are maintained or increased, such storage construction may be a costly waste of resources. Elevator and annex construction is far more costly than farm storage. Elevator companies state that it costs approximately $2.00 a bushel to build country elevators and over $5.00 a bushel to build grain terminals. Farmers can construct grain storage space for less than 50 cents a bushel.

4. Within the shipping blocks or even alternate blocks for that matter, commercial trucks could provide desired flexibility in that they may move grain to elevators farther distances apart at a cheaper rate, than it costs to provide rail service into a number of lighter traffic lines.

Implications to the Quota System

As long as a quota system[7] is implemented to provide producers with reasonable equal delivery opportunities at times when production of grain exceeds the market demands; and further, as long as the quotas implemented are for the quality and type of grain demanded in the market, there should be no serious problems created by the fact of utilizing commercial trucks to haul further distances to elevator points. That is,

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[7] Om P. Tangri and E. W. Tyrchniewicz, "Grain Delivery Quota System - Time for a Change?" Spotlight, (Faculty of Agriculture and Home Economics, University of Manitoba, Winnipeg, Volume II, No. IV, December, 1967), pp. 15-16.

no bottlenecks should occur in the system that would hinder marketing. Some technical problems will arise that need consideration.

1. Under present regulations, over-delivery on a quota is punishable by law. It should be suggested that when producers are forced to haul longer distances to elevators, it could become costly to travel 30 miles only loaded with 150 bushels to fill a quota when the truck will carry 300 bushels. Perhaps in this area a preferential storage clause at minimal cost could be legislated, to account for over-delivery or some other method of quota adjustment on later quotas. The important point to be made, is that this problem will exist and need a solution.

2. Queuing at elevators is another potential problem. However, if elevators were placed at greater distances apart many of the small vehicles now used by farmers may become inoperative, and more commercial vehicles employed. In general, this should not be too serious a problem.

3. There is the problem of making sure farmers deliver the type of grain that the elevator can accept. Having to return home with a load of grain not of the quality asked for under the new quota program, could be a costly business. Perhaps some advance sample submission system by producers to elevator managers would alleviate this problem.

SUGGESTIONS FOR FURTHER RESEARCH

Numerous problems will arise under the proposal to haul grain further distances by commercial truck.

1. The most important problem to solve at this time is the optimum distances between elevator points. This problem could be answered by finding the maximum mileage, that trucks hold cost advantages over the railways.

2. A new proposed system would require, perhaps, more revenue

from the handling of grain and less for the storage provided.

In general, there are a number of problems that will arise, but if research programs are carried out in these problem areas, sound proposals may be made by 1975, (1975 is when the Canadian Transport Commission removes the freeze on rail abandonment and discussions are renewed). If the research is neglected and planning is not carried to the required stage by 1975, the grain industry of Western Canada can perhaps prolong its present situation with further Federal Goverhment subsidies. However, it would seem that such measures do not solve the problems of the industry, but rather postpone them until they become large enough that drastic measures may be required.

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APPENDIX A

DESCRIPTION OF THE SAMPLE

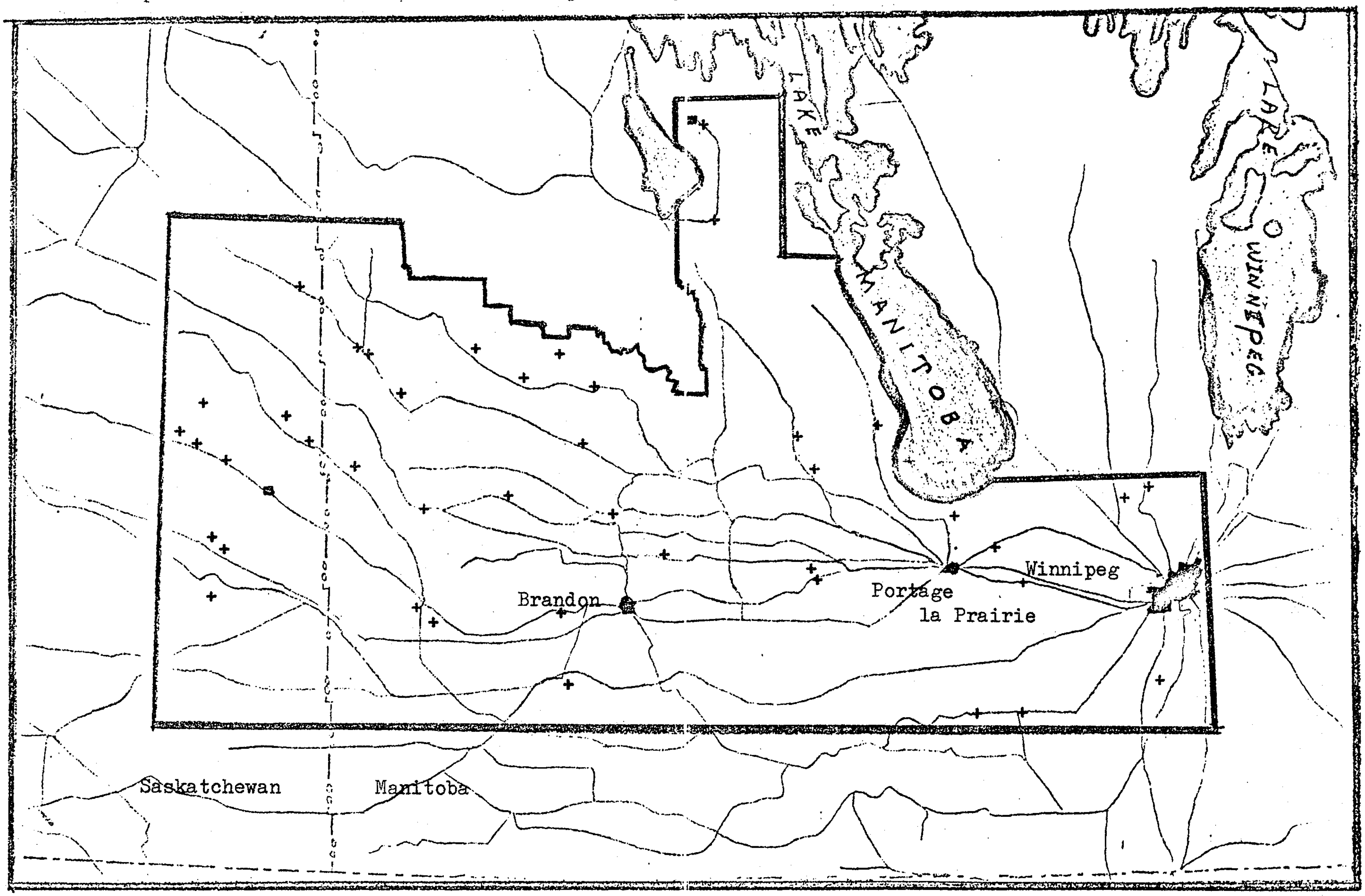
Although it may have been preferable to take a sample of truckers from all over the prairies, this was not done because of financial constraints. The approach taken was to select a given area or block within the prairie region. The area chosen was considered to be representative of the entire prairie area. In selecting the block to be sampled, the following factors were considered:

1. farm types, (grain, mixed farms, etc.)
2. farm size
3. soil variation
4. road conditions
5. variation in distance to elevator points
6. terrain variation.

The block selected is shown as Map I. It was felt that this area complied with all the factors necessary to be reasonably representative of the Canadian prairies, and in all instances this area should return the information desired to fulfill the objectives of the study.

After the block to be sampled was established, it was found that three elevator companies had elevators in at least 95 percent of the delivery points. Arrangements were made with these companies: Manitoba Pool Elevators, United Grain Growers Limited, and the Federal Grain Company Limited, to submit a questionnaire to their agents to secure the names of all commercial and custom truckers that haul grain to their elevator points within the block. On the questionnaires

Map 1. The Block Area Used in the Sample Survey.



+indicates the locations of the 45 truckers in the sample.

returned by the elevator agents, there were a total of 300 truckers names listed. Because of the time element involved in taking the survey and the financial limitations of the project, the entire 300 truckers were not surveyed. By utilizing a random sampling procedure, 107 names of truckers were selected within the block area as the sample to represent the entire prairie commercial grain truckers' population. The 107 names appeared to be adequate as a sample size given the available research resources. Because each of the truckers selected in the sample was independent of the others, it was felt that a sample of this size would not be detrimental to the results of the study.[1]

A concerted effort was made in an attempt to have the 107 questionnaires completed, by mailing them out to the truckers and making a personal visit to each of the truckers in the survey. However, for personal reasons many of the truckers would not comply with the request to fill out the questionnaire. The final number of completed questionnaires was 45. The assumption was made that the 45 truckers who did fill out the questionnaire represented an unbiased random sample of the 107 originally chosen.

The completed questionnaires[2] were answered in detail with minimal speculation or estimation on the part of the truckers in arriving at figures. The time period under investigation was the 1967-68 crop year. Because the time period was current, most records were readily available.

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[1]For a more detailed discussion of sample size see: William A. Spurr and Charles P. Bonini, Statistical Analysis for Business Decisions, (Richard D. Irwin, Inc., Homewood, Illinois, 1967), p. 268.

[2]See Appendix F for a copy of the questionnaire used in the analysis.

The reasons for the choice of this particular period were twofold: (1) a full year grain movement cycle was considered, and (2) it was the most recent year available that had up-to-date cost figures. At the time the survey was made (July, 1969), the 1968-69 crop year had not been completed.

The 45 trucks used to haul grain varied in size from one to five tons. However, the majority of the trucks were three tons.[3] The trucks ranged in age from 1950 models to 1968 models. Some of the vehicles travelled very low mileages during the year, while other mileages were extremely high.[4]

Most of the trucks in the sample were utilized to the greatest extent for hauling grain. However, some trucks received a low proportion of their total business in transporting grain.

By utilizing to the fullest extent the information received from the sample, it was anticipated that realistic costs of transporting grain from farms to country elevators would be obtained. There is little evidence in the industry that truckers themselves know what their actual costs are with regard to the movement of grain. Even if there was this knowledge among truckers, it is not conceivable that the information would become known to the industry at large, for comparisons between operations. At the present time, rates charged for the hauling of grain seem to be established by what is known as "the seat of the pants method".

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[3]The breakdown according to size was as follows: 5 one and two tons, 32 three tons, and 8 four and five tons.

[4]Some vehicles travelled less than 2000 yearly miles, while one truck travelled 45,000 miles in the year.

The price charged is based on a value of service.[5] The problem which arises here is that producers do not objectively know what the value of service is. The price is set according to subjective rules of considered business necessity, rather than objective cost analysis. If complete costing analysis and accounting records were kept by commercial grain truckers, there would be no need for this study. However, the information is not available and the possibility of rail abandonment has created an urgent need for an assessment of trucking costs.

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[5]For further information on value of service pricing, refer to: G. W. Wilson, Essays on some Unsettled Questions in the Economics of Transportation, (Graduate School of Business, Indiana University, 1962), p. 149; A. W. Currie, Canadian Transportation Economics, (University of Toronto Press, 1967), p. 130.

APPENDIX B

LITERATURE REVIEW

The literature available in the area of this study is limited and generally does not consider the same aspects that are involved in this research. Casavant and Nelson completed a study in North Dakota to determine the costs of operating grain trucking firms.[1] Their cost findings are not particularly relevant to the Canadian situation, because the movement of grain considered was by tractor trailer units. The grain hauled was to seaboard positions which is far in excess of any truck movements anticipated in Canada at the present time. The mileage differential between the American study and this one could make a considerable difference in the estimated average cost.

However, there were certain findings in the North Dakota study that enabled comparisons of specific variables. Comparisons could be made of the percentage of backhauls and the cost of tire wear. Backhauls are an important consideration when determining trucking revenues and costs in product movement between centers. The movement in the U. S. study was between larger centers and it was found that two-way movement was very limited.

> The North Dakota grain trucker seldom hauls commodities on his return trip. Added effort in this area may offer high potential increased efficiency. Of the total mileage driven, 62 percent were loaded miles. This means that only 24 percent of the return trip mileage were loaded miles.[2]

Backhauls between farms and country elevators would be even more

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[1]Kenneth L. Casavant and David C. Nelson, An Economic Analysis of the Costs of Operating Grain Trucking Firms in North Dakota, (Department of Agricultural Economics, Agricultural Experiment Station, North Dakota State University, Fargo, North Dakota, July, 1967).

[2]Ibid.

limited. The only areas where such movement may occur is in the case of seed, fertilizer, and other farm supplies. However, the probability of the quotas increasing at the time, or on the specific day that given commodities are required at the farm, is extrememly small. Although there was no analysis of this subject, the backhauls are sufficiently small, so they can be ignored.

Another interesting cost comparison between this study and the North Dakota study is with regards to tire wear. The cost attributed to tire wear by Casavant and Nelson was 2.5 cents per mile. The largest truck considered in this study was a five ton single unit, while the North Dakota study included tractor-trailer combinations. It appears that the cost figures for tire wear of this study are extremely close to Casavant and Nelson's for larger vehicles. This is because of the increasing costs attributed to tire wear as the size of vehicle increases. A clear comparison of these costs is illustrated in Appendix C, Table C4.

In a study completed by Young, two models were developed to establish farm truck operating costs.[3] Young's model was based on the following equations:

$$\text{Model I:} \quad Y = a + b_1X_1 + b_2X_2$$

$$\text{Model II:} \quad Y = aX_1^{b_1} X_2^{b_2}$$

where, Y = the cost of moving grain in terms of cents per bushel-mile

X_1 = the size of the truck in terms of load capacity

X_2 = the average distance of haul to the elevator point of delivery

a = the constant that positions the function

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[3]K. B. Young, An Analysis of the Cost of Assembling Grain by Farm Trucks in Manitoba, Department of Agricultural Economics and Farm Management, University of Manitoba, Research Report No. II, October, 1966).

b_1 and b_2 = the regression coefficients that stipulate the relationship between the dependent variable and the independent variables, in terms of elasticity for the Cobb-Douglas equation and slope for the linear equation.

There are however, variables other than the two found to be significant by Young, that can help determine the cost of grain hauling. Variables such as total miles, type of road surface, age of truck, total yearly volume, labour costs, and the proportion of the total yearly miles hauling grain, will all have an effect on grain trucking costs. These variables are more important to commercial truckers because of the different types of produce hauled and the various locations from which each truck hauls. It is likely true that reasonable answers could be obtained with Young's model for farm trucks; however, it was not intended to determine costs for commercial trucks.

The type of road surface travelled may have little effect on estimated costs because in a short time period the percentage of each type of road surface travelled upon is constant. However, when considering a predicting[4] equation, generally a long-run period is considered. In the long-run, the percentage of miles on the different types of road surfaces could change considerable and therefore have a significant effect on future costs. If it is intended to explain present cost relationships, it may be permissible to delete variables from the equation. On these grounds, Young may be justified in explaining 46 percent of the variation of the dependent variable, namely the trucking costs; however, for prediction purposes there are too many variables omitted from the farm

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[4]Predicting, in this case, is using a developed model to forecast future costs of hauling grain.

truck model to use it satisfactorily for custom or commercial trucks. While one important aspect of this study is to determine the current costs of various cost elements in grain trucking, the model will be developed such that it can also predict grain hauling costs in the future.

The appropriate way to interpret Young's study is to treat it as an accounting analysis of farm trucking costs. To place emphasis on his model for purposes of prediction, requires that the various aspects mentioned above be taken into full consideration.

Another Canadian study completed on grain assembly cost by Groundwater and Winter[5] assessed costs on a sample from the Peace River block of Alberta. The cost of operating a grain truck in the Peace River area was shown to be 44.8 cents per mile. The Groundwater and Winter cost figure for trucking grain is higher than the one found in this study. Their calculated cost may be attributed to poorer road conditions in the Peace River area. However, the Groundwater and Winter estimate was derived from the Young model. These results are questionable because of the aforestated limitations of the model.

A study by Riordan pointed out that in the case of the smaller farmers, costs incurred to purchase larger trucks where necessitated or desired, would exceed any savings created by making fewer trips to elevator points.

When a farmer moves his grain, it is mainly the cost of truck operation and driving time that vary with choice of

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[5] R. A. Groundwater and G. R. Winter, <u>Cost Components in Grain Assembly</u>, (Department of Agricultural Economics, University of British Columbia, July, 1969).

> selling point. For the present purpose operating costs comprise outlay on fuel, lubrication, tires, maintenance, and depreciation due to use. Other costs such as depreciation due to lapse of time, interest on capital, and licensing do vary with vehicle use. In many cases the increase in these latter costs through owning a larger truck would exceed the savings in operating costs secured by reducing the number of journeys.[6]

On the basis of the previous quotation, it appears that commercial trucking could play a significant role in grain movement, especially in the light of elevators spaced at greater distances. Riordan's study relied on information for trucking costs from other published sources.[7] Further, only farm trucks were considered. One aspect of the study was to consider the allocation of farm trucking costs based on different types of road surfaces.[8] Since the Riordan study did not explicitly examine commercial or custom trucking, it had little influence on this study.

The 1961 census shows that 75 percent of the farmers in Manitoba owned their own trucks.[9] According to a survey conducted by Butler[10],

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[6]E. B. Riordan, Spatial Competition and Division of Grain Receipts Between Country Elevators, (Unpublished Master of Science Thesis, University of Manitoba, February, 1965), p. 29.

[7]Custom Rates Per Acre in the Province of Saskatchewan as Shown by Mail Questionnaire Survey Through Wheat Pool Locals, (Saskatoon: Department of Farm Management, University of Saskatchewan and Dominion Economics Branch), p.2.

[8]E. B. Riordan, op. cit., p. 44.

[9]Dominion Bureau of Statistics, 1961 Census of Canada, Agriculture Manitoba Bulletih S-3-1, (Ottawa Queen s Printer and Controller of Stationery, 1963).

[10]A. H. Butler, A Cost Analysis of Transferring Grain by Farmer Owned and Operated Trucks, (Master of Science Thesis, unpublished, University of Manitoba, Winnipeg, October, 1970).

only 5.8 percent of the farmers had their grain hauled by commercial trucks. Butler's survey was taken in July, 1969. The difference between this survey and the census of 1961 could be interpreted to mean that more farmers are hauling grain with their own trucks, and also Butler excluded all producers who did not have delivery permit books. Previous surveys in Southern Manitoba also indicate a very low number of farmers hire commercial trucks to haul their grain. In a sample of 300 farms ranging in size from two to five quarter sections, only eight employed a commercial trucker.[11]

These are indications that grain producers require their trucks to render services other than the hauling of grain from the farm to elevator points. In many instances, the condition of the farm trucks would not allow producers to haul increased distances, were elevators to be spaced further apart. However, if rail lines are allowed to be abandoned, the type of truck desired to fill the gap most efficiently should be known. In order to find cost efficiency in trucks, several problem areas must be considered in detail.

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[11] J. G. MacKenzie, Farm Organization - Somerset - Manitou Area, 1959; Changes in Farm Organization - Reston - Elkhorn Area, Manitoba, 1960; Changes in Farm Organization - Russell - Minnedosa Area, Manitoba, 1961; L. M. Johnson, Changes in Farm Organization - Red River Valley Area, Manitoba, 1962, (Winnipeg: Canada Department of Agriculture, Economics Division, Table 10).

APPENDIX C

EMPIRICAL HANDLING OF THE MAJOR COST VARIABLES

Depreciation

In Chapter II it was shown that depreciation was one of the more important cost considerations and problems. However, as was established, the problem has no simple solution. There are cases where the real market value of the vehicle does not correspond to the book value, as determined by the diminishing balance method at 20 percent. The following is an actual case from the sample that illustrates the problem. The truck being examined is a three ton, purchased new in 1961, and depreciated at 20 percent per year. Column A shows the diminishing balance method, and Column B shows the market implications between purchase price in 1961 and resale value in 1968 (i.e., the average depreciation).

The striking difference shown in Table C1 causes consideration of alternative processes in the calculation of depreciation. The average depreciation in Column B is calculated by subtracting the 1968 value (\$1500.00) from the 1961 value (\$3200.00) and then dividing by the number of interim years. That is:

$$\frac{\$3200 \;-\; \$1500}{1968 \;-\; 1961} = \frac{\$1700}{7} = \$242.85$$

The \$242.85 is the real average loss in value to the trucker over each year the truck operated. In other words the cost assessed to the operation of providing a cash reserve for replacement of the truck is \$242.85 for the 1967-68 crop year. The diminishing balance method would assess a depreciation cost of \$151.00 for the same time period. The \$151.00 is

Table C1. Comparison of the Diminishing Balance and the Average Methods of Calculating Depreciation

	A	B
New Value	$3200.00	$3200.00
1961 Dep.	640.00	242.85
1962 Value	2560.00	2957.15
1962 Dep.	512.00	242.85
1963 Value	2048.00	2714.30
1963 Dep.	409.60	242.85
1964 Value	1638.40	2471.45
1964 Dep.	327.68	242.85
1965 Value	1310.72	2228.60
1965 Dep.	262.14	242.85
1966 Value	1048.58	1985.75
1966 Dep.	209.72	242.85
1967 Value	838.86	1742.90
1967 Dep.	167.77	242.85
1968 Value	671.09	1500.05

calculate as follows:

$$\frac{20\% \text{ of } 1967 \text{ value}}{2} + \frac{20\% \text{ of } 1968 \text{ value}}{2} = \frac{\$167.77}{2} +$$

$$\frac{\$134.21}{2} = \$151.00$$

The difference between the two depreciation methods for the specified year is \$242.85 - \$151.00 = \$91.85. Because there are discrepancies in methods of calculating depreciation, it was decided that both methods mentioned here would be used. The object of the effort would be to see what difference, if any, there would be in the total average cost of depreciation between the two methods.

The difference in the average of the two methods would suggest that the diminishing balance method of calculation using 20 percent, tends to write off the real value, sooner than would be the case in the market. However, the one and two ton trucks showed that the average depreciation method reduced prices of trucks faster than did the diminishing balance method. The weighted averages of the aggregate for all trucks are illustrated below.

Table C2. The Aggregate Average Depreciation Comparison for all Trucks

Truck Size	Number in Sample	Total Average by Average Depreciation	Total Average by Diminishing Balance
1 and 2 tons	8	\$474.72	\$431.93
3 tons	32	299.51	467.47
4 and 5 tons	6	718.49	1005.51

The attention paid to the variation of the two methods of depreciation in this study should give a clearer understanding of the problems involved with its calculation. Also substantiated, is the fact that market value prices of trucks are of prime concern when determining a real economic cost factor. It would be naive indeed, to illustrate a method of depreciation which did not return the real economic costs attributed to it, and furthermore this research is not really interested in strict accounting procedures, but rather economic costs. The conclusion arrived at in this study with regards to depreciation is that there is very little difference in the two methods. The small percentage difference between the two types of depreciation, and the total cost of operating trucks, will not have much effect on the over-all trucking costs. Much of the discrepancy could be attributed to the percentage used in the calculation of the diminishing balance.

Interest on Investment

Trucks: The interest on investment was assessed at 7 percent per annum. The opportunity returns for investment at that time was very close to 7 percent. In cases where truckers have payments on loans, a 3 percent adjustment was calculated. Further adjustments can be added in sequences, until the loan rate of interest is obtained. The objective of these adjustments was to indicate extra costs incurred by financing the purchase of a vehicle. The 3 percent increment adjustments does not mean that a trucker pays 10 percent for a loan, it merely attempts to point out that a trucker who has to borrow money to purchase a truck has more expenses to cover than one who does not have to borrow. Because the interest on investment, and the interest payments on loans were not a substantial portion of total costs, 3 percent increments were felt to display adequately any effect on the total costs. (Interest on investment varied from 6.8 percent of total cost to 13.4 percent, depending on the size of the truck.)

Buildings: The interest incurred on building investment was calculated at 6 percent. For the most part this cost is insignificant. Only six truckers out of the forty-five, housed their vehicles. The life of the buildings was considered to be 20 years and therefore they were depreciated at 5 percent per annum.

Other Fixed and Variable Costs

Other fixed cost values such as insurance, license, housing and utilities, were taken directly from the questionnaires as given. The variable costs such as tires and batteries, lubrication, repairs, fuel cost, hired and personal labour, were also calculated directly from the information on the questionnaires.

An Analysis to Determine Tire Costs

Tire costs create some problems that must be considered. The information received on the questionnaires indicated that some truckers had purchased new tires in the 1967-68 crop year. Other questionnaires showed no expenditures on tires, even though they would have incurred some wear in that year. Intuitively, it seems that to rationalize the costs of tires correctly, they should be assessed on a mileage basis. As the questionnaire data yielded only the expenditures for the given year it became necessary to find the average cost of all trucks for yearly tire wear. If it is assumed that the sample is large enough to cover the entire range of costs, it can be assumed that the average of the sample will give us a good estimate of real tire costs.

Before examining what the data of this research gave as a tire cost, it is worthwhile to consider what other studies have indicated as being the tire cost per mile.

The Submission to the Royal Commission on Northern Transportation, by Gardewine and Sons Limited, April, 1968, show tire costs per mile as follows:

Table C3. Costs in Cents per Mile which are Affected by Road Surface

	Good Gravel	Crushed Rock	Pavement
Tractor Tires	1.7	4.3	1.0
Trailer Tires	1.3	3.5	.8

Source: Gardewine and Sons Limited, The Submission to the Royal Comission on Northern Transportation, (April, 1968), p. 13.

The study in North Dakota by Casavant and Nelson, stated the following about tire costs.

> Many factors result in wear on the tire. When the tire is first placed on the vehicle, wear is comparatively rapid. As the tire wears down the rate of wear slows appreciably. A cost per mile of 2.5 cents was used, arrived at by dividing the mileage per tire into the average purchase price per tire multiplied times the number of tires on each tractor-trailer combination.[1]

It should be taken into account that in both of the above studies, large trucks were considered, i.e., four tons and tractor-trailer units. However, results of this study do indicate that larger trucks are more expensive with regards to tire costs. The following table shows the results of this analysis.

[1]K. L. Casavant and D. C. Nelson, An Economic Analysis of the Costs of Operating Grain Trucking Firms in North Dakota, (Department of Agricultural Economics, Agricultural Experiment Station, North Dakota State University, Fargo, North Dakota, Agricultural Economic Report No. 54, July, 1967), p. 21.

Table C4. The Costs of Tire Wear in Cents per Mile for Various Sizes of Trucks

	Cost in Cents per Mile	Percent of Miles on Different Road Surfaces		
		Earth	Gravel	Paved
1 and 2 tons	1.05	19.2	74.2	6.6
3 tons	1.65	9.6	61.7	29.7
4 and 5 tons	1.89	13.8	18.2	68.0

The tire costs per mile in this study were calculated in the following manner. The average cost of tires in cents per bushel-mile that was charged to the different sized vehicles was multiplied by the size of the average load and then divided by two. The division by two is made to account for the cost of empty miles which are included in the average cost per bushel-mile.

Example: The cost of the one and two tons was .0117 cents per bushel-mile. The size of the average load was 180 bushels.

$$\frac{.0117\ (180)}{2} = 1.05 \text{ cents per mile}$$

A similar approach was used for the other sizes of vehicles.

Labour

In many instances labour is a difficult cost factor to assess. The major reason for this is the lack of knowledge on the part of truckers as to the value of their time. In a majority of cases, management and labour are considered as one. When interviewing truckers it was found that in some cases the distribution of costs was irrelevant to them. The most important criterion to truckers was to end up in "black figures"[2] at the year end.

[2]Black figures is the accounting term that indicates revenues are in excess of costs.

In the majority of cases in this study, the cost of labour can be considered as an opportunity cost. The truck operators are generally the owners, and review their return to labour as being what they would receive on the market for a similar occupation. In very few cases in this survey did truck owners hire drivers for the purpose of hauling grain. Where such employment was indicated, the actual wages paid to the driver were included in the calculation of the average wage.

Total labour costs were considered as three distinct categories:

1. Driver labour - labour required to drive the truck from point of load to unload

2. Dead haul labour - labour time considered in loading time, unloading time, and waiting at unload

3. Maintenance labour - personal or hired labour required to keep the vehicle in service.

APPENDIX D

FORMULAS FOR CALCULATION OF THE COST VARIABLES

Fixed Costs

Average depreciation:

$$\frac{\text{total average dep. \$ x 100 cents x \% of miles hauling grain (two-way)}}{\text{total bushel-miles}}$$

= average depreciation in cents per bushel-mile

Diminishing balance depreciation:

$$\frac{\text{total diminishing balance dep. \$ x 100 cents x \% of miles hauling grain (two-way)}}{\text{total bushel-miles}}$$

= diminishing balance depreciation in cents per bushel-mile

Insurance:

$$\frac{\text{total insurance \$ x 100 cents x \% of miles hauling grain (two-way)}}{\text{total bushel-miles}}$$

= insurance cost in cents per bushel-mile

License:

$$\frac{\text{total license \$ x 100 cents x \% of miles hauling grain (two-way)}}{\text{total bushel-miles}}$$

= license cost in cents per bushel-mile

Utilities:

$$\frac{\text{total utility \$ x 100 cents x \% of miles hauling grain (two-way)}}{\text{total bushel-miles}}$$

= utilities cost in cents per bushel-mile

Variable Costs

Tires and batteries:

$$\frac{\text{tires and batteries \$} \times 100 \text{ cents} \times \text{\% of miles hauling grain (two-way)}}{\text{total bushel-miles}}$$

= tire and battery costs in cents per bushel-mile

Lubrication:

$$\frac{\text{lubrication cost \$} \times 100 \text{ cents} \times \text{\% of miles hauling grain (two-way)}}{\text{total bushel-miles}}$$

= lubrication cost in cents per bushel-mile

Repairs:

$$\frac{\text{repair cost \$} \times 100 \text{ cents} \times \text{\% of miles hauling grain (two-way)}}{\text{total bushel-miles}}$$

= repair cost in cents per bushel-mile

Fuel Cost:

Fuel costs were calculated based on the miles per gallon of each truck and the price paid per gallon for fuel. The formula used to arrive at a total cost of fuel is as follows.

$$\frac{\text{total miles travelled}}{\text{average miles / gallon}} = (\text{number of gallons}) \times \text{price per gallon}$$

= total cost of fuel

To convert the total cost to cents per bushel-mile, the following formula was used:

$$\frac{\text{total cost of fuel \$} \times 100 \text{ cents} \times \text{\% of miles hauling grain (two-way)}}{\text{total bushel-miles}}$$

= fuel cost in cents per bushel-mile

Labour Costs

Hired maintenance labour:

$$\frac{\text{total cost \$ for maintenance labour x 100 cents x \% of miles hauling grain}}{\text{total bushel-miles}}$$

$=$ maintenance labour cost in cents per bushel-mile

Personal maintenance labour:

Where personal labour was employed to repair the truck, the number of hours spent was multiplied by the average value of labour per hour ($1.82).

$$\frac{\text{total personal maintenance cost \$ x 100 cents x \% of miles hauling grain}}{\text{total bushel-miles}}$$

$=$ personal labour maintenance in cents per bushel-mile

Dead haul charge to labour:

The dead haul charge is that charge applied to labour for the period of time when the truck is being loaded, unloaded, or waiting in line at country elevators. It was calculated in the following manner:

$$\frac{\text{total minutes charged to dead haul}}{\text{60 minutes}} \text{ x \$1.82/hour} \div \text{bushel-miles}$$

$=$ dead haul charge in cents per bushel-mile

Driving labour:

The driving labour was calculated from the time of farm departure until the time of reaching the elevator. The calculation was made by utilizing the number of load miles hauling grain, and the average travelling speed under load.

The nature of a custom trucking operation made it necessary to weight all the cost variables by the proportion of miles hauling grain. In some instances, the volume of grain hauled as a percent of total business was small. This relationship can be seen in Chapter III. Because the volume of grain moved in some instances was a small proportion of the total business, the number of miles travelled in tending to grain business was also a small proportion of total miles. The miles travelling empty and the time involved were all charged to the loaded miles.

APPENDIX E

Table E1. Average Fixed Costs as a Percentage of Total Costs Weighted to Miles Hauling Grain for all Sizes of Trucks

Truck Size	Average Deprec.		Insurance		License		Utilities		Housing		Interest on Investment		Total Cost
	Cost	%	Cost	%	Cost	%	Cost	%	Cost	%	Cost	%	
1 and 2 tons	.1315	27.3	.0114	2.4	.0210	4.6	.0014	0.3	.0011	0.2	.0492	10.2	.4859
3 tons	.0453	17.4	.0057	2.2	.0119	4.6	.0046	1.8	-	-	.0350	13.4	.2609
4 and 5 tons	.0180	13.9	.0030	2.2	.0042	3.2	.0003	0.2	.0003	0.3	.0088	6.8	.1297

Table E2. Average Variable Costs as a Percentage of the Total Costs Weighted to Miles Hauling Grain for all Sizes of Trucks

(1)

Truck Size	Tires & Batteries		Lubrication		Fuel		Hired Maintenance Labour		Dead Freight	
	Cost	%	Cost	%	Cost	%	Cost	%	Cost	%
1 and 2 tons	.0117	2.4	.0322	6.6	.0384	7.9	.0048	0.9	.0490	10.1
3 tons	.0115	4.4	.0064	2.5	.0400	15.3	.0015	0.6	.0343	13.1
4 and 5 tons	.0084	6.5	.0043	3.3	.0260	20.0	.0012	1.0	.0114	8.8

(2)

Truck Size	Personal Maintenance Labour		Personal Driving Labour		Hired Driving Labour		Repairs		Total Cost
	Cost	%	Cost	%	Cost	%	Cost	%	
1 and 2 tons	.0082	1.8	.0732	15.3	.0111	2.3	.0381	7.9	.4859
3 tons	.0030	1.2	.0434	16.7	.0058	2.2	.0120	4.6	.2609
4 and 5 tons	.0014	1.1	.0166	12.8	.0111	8.6	.0146	11.3	.1297

APPENDIX F

QUESTIONNAIRE

ON

COST OF MOVING GRAIN BY TRUCK

Name ______________________________ Number __________

Address ______________________________

Please indicate which of the following categories best describes your operation. Check only one. (See definitions below.)

(a) a farmer _____
(b) a farmer and custom trucker _____
(c) a commercial trucker _____
(d) a commercial trucker and a farmer _____

For purposes of this study a commercial trucker is a trucker with a P.S.V. license. A custom trucker is one with a farm license or standard license for delivering in smaller areas, and who delivers other people s as well as his own products.

INSTRUCTIONS

1. Farmers only fill out the questions in Part A, D and the relevant sections in Part C.
2. Farmers who do custom trucking besides their farming operation fill out Parts A, B, C and D.
3. Commercial truckers fill out Parts B and C.

PLEASE LIST OR ESTIMATE ANSWERS AS ACCURATELY AS POSSIBLE.

PART A FOR FARMERS ONLY 1967-68 CROP YEAR

1. Land Description:

Parcels	Owned or Rented	Qtr.	Sec.	Twp.	Rge.	M	Cultivated Acreage	Grain Storage Volume Per Parcel (bushels)
1								
2								
3								
4								

2 (a). Volume and Method of grain delivery during 1967-68 crop year

Crops Grown	1967-68 Crop year total bushels for the year delivered to elevator or other outlet	% of Grain Drawn By Own Truck	% of Grain Drawn by Tractor	% of Grain Drawn by Custom Truck	% of Grain Drawn by Other	Total Miles One-Way To Outlet
Wheat						
Oats						
Barley						
Rye						
Flax						
Buckwheat						
Rapeseed						
Peas						
Others						

To include sales other than to the Canadian Wheat Board, e.g., sales to mills, feeders, etc.

2 (b). Bushels delivered from each Parcel in 1967-68

	Parcel 1	2	3	4	5	6	7	8
Wheat								
Barley								
Oats								
Flax								
Rapeseed								
Other								

2 (c). Type of road surface and distance from each parcel of land with grain storage to delivery point (1967-68) and to other outlets (e.g. feed mills)

		Delivery Point	Other Outlets
Parcel 1:	miles of earth road	____	____
	miles of gravel road	____	____
	miles of paved road	____	____
	Total	____	____
Parcel 2:	miles of earth road	____	____
	miles of gravel road	____	____
	miles of paved road	____	____
	Total	____	____
Parcel 3:	miles of earth road	____	____
	miles of gravel road	____	____
	miles of paved road	____	____
	Total	____	____
Parcel 4:	miles of earth road	____	____
	miles of gravel road	____	____
	miles of paved road	____	____
	Total	____	____
Parcel 5:	miles of earth road	____	____
	miles of gravel road	____	____
	miles of paved road	____	____
	Total	____	____
Parcel 6:	miles of earth road	____	____
	miles of gravel road	____	____
	miles of paved road	____	____
	Total	____	____

3 (a). Types of road surface and total distance travelled during the 1967-68 crop year in delivering grain from the combine to farm storage facilities

_______ % of miles on pavement

_______ % of miles on gravel

_______ % of miles on dirt

(b) Total miles Inter-Farm Feed Grain Hauling _______

(c) Estimate of total miles hauling grain from combine to farm storage _______

4. Average time required to move grain from farm storage to delivery point

	Truck A	Truck B	Truck C
(a) Loading	______ min.	_____ min.	_____ min.
(b) Unloading	______ min.	_____ min.	_____ min.
(c) Waiting time	______ min.	_____ min.	_____ min.
(d) Travelling speed	______ mph.	_____ mph.	_____ mph.

5. Is the grain delivery point used the closest to your farm?

Yes ____ No ____

If no, please check the most appropriate of the following:

(1) Poor roads _____

(2) Poor elevator service _____

(3) No elevator competition _____

(4) "Other" Please specify _______________

6. What portion of your gross revenue came from the following sources during the crop year 1967-68?

(a) Sales of grain _______ %

(b) Sales of livestock ________ %

(c) Custom grain hauling ________ %

(d) Other custom work ________ %

(e) Other (specify) ____________ %

Total 100 %

PART B

7.(a) What did you charge to haul grain in cents / bushels for the following: 1967-68 crop year

Distance	Wheat	Oats	Barley	Rye	Flax	Rape	Other
1 mile							
2 miles							
3 miles							
4 miles							
5 miles							
6-10 miles							
11-15 miles							
16-25 miles							
26-50 miles							
Over 50 miles							

7 (b) Would the same rate apply today? ____
If not, why not? ______________________________

7 (c) Is there a loading and unloading charge plus a per mile charge?
Yes ____ No ____

8. Average time required by commercial and custom truckers to:

	Truck A	Truck B	Truck C
(a) load	____ min.	____ min.	____ min.
(b) unload	____ min.	____ min.	____ min.
(c) waiting time	____ min.	____ min.	____ min.
(d) travelling speed	____ mph.	____ mph.	____ mph.

9. Do you custom haul all year round? Yes ____ No ____
If no, please explain why

(1) insufficient business ____________

(2) custom hauling is a supplementary enterprise ____________

(3) Other ______________________

10. What did you custom haul during the 1967-68 crop year, August 1, 1967 to July 31, 1968?

						Others
Grain	_____ bus.	Feed	_____ tons			__________
Gravel	_____ yds.	Cattle	_____ head			__________
Coal	_____ tons	General freight		_____	tons	__________

11. Type of road and total distance travelled in the year s operation of hauling grain

% of miles on earth roads __________

% of miles on gravel roads __________

% of miles on hard surfaced roads __________

12.(a) Do you charge different rates depending on the road surface? If so, what are the differences? ____________________

____

(b) Do you have a minimum road charge? Yes ____ No ____
If yes, what would it be? __________

(c) Do you have a minimum charge regardless of the size of the load? Yes ____ No ____
If yes, what is the load size? ________, and the minimum charge? ________.

(d) Do you have different rates depending on terrain?
Yes _____ No _____
Explain ____________________

____

(e) Do you rent trucks for your own use? Yes ____ No ____
Other uses? Yes ____ No ____ Charges? ________

13. Do you use your own loading equipment in custom hauling?
Yes _____ No ____
If yes, what are the charges made? __________

14. What do you charge to haul the following:

Gravel	__________	¢ /yard
Coal	__________	$ /ton
Feed	__________	$ /ton
Cattle	__________	$ /head or ________ ¢ /cwt.
General freight	__________	¢ /cwt.
Miscellaneous	__________	

15. What proportion of your business (gross revenue) was made up of grain hauling in 1967-68?

____

____

PART C

This section is to be answered by farmers, custom truckers, and commercial truckers. Crop year 1967-68.

16. Trucks

	Truck A	Truck B	Truck C
Size			
Make			
Year			
Number of cylinders			
Year & month of purchase			
Price paid			
Present value			

17. Truck Repairs

	$	$	$
tires and batteries			
grease oil and filters and antifreeze			
tune up and repairs			
overhauls			
personal hours repairing	hrs.	hrs.	hrs.
hired hours repairing at home	hrs.	hrs.	hrs.

18. Truck Housing

type of facility used			
value of building	$	$	$
portion of building used to house trucks	%	%	%
repairs to building facilities	$	$	$

19. Utility Cost

heat	$	$	$
hydro	$	$	$
telephone	$	$	$
value of shop equipment for truck maintenance	$	$	$

20. Price paid for gasoline or diesel fuel per gallon — gas ______ diesel ______

Average truck miles per gallon ______

21.

	Truck A	Truck B	Truck C
License costs			
Insurance costs			
Other costs (specify)			

22.

Labour costs (Total hrs. trucking)		$/hr. value/hr.	Maintenance hours
self employed and unpaid family			
hired seasonal labour			
permanent hired labour			

23 (a)

Mileages	Truck A	Truck B	Truck C
total truck mileage			
miles driven during the year			
% miles hauling own grain			
total miles hauling custom grain			

(b)

% total miles hauling custom grain under load ______

total bushels of custom hauling of:

wheat	
oats	
barley	
rye	
flax	
rapeseed	
other	

(c)

	Truck A	Truck B	Truck C
% of total miles of commercial hauling			
% of total miles of commercial hauling under load			
total bushels of commercial hauling of:			
wheat			
oats			
barley			
rye			
flax			
rapeseed			
other			

24. Box capacity in wheat bushels ______

Average load carried in wheat bushels ______

SUPPLEMENTARY PART D

25.

	Shipping point or town where the following services are obtained	Miles from farm	If your rail line were abandoned, would you go to an alternate town?	Name of alternate town	Miles from farm
Mail					
Groceries					
Light Shopping					
Major Shopping					
Repairs					
Machinery Purchases					
Grain Delivery					
Recreational Center					
Others					

26. If your delivery distance were to increase would you require a newer or larger truck, or would you use commercial facilities?

27. Under present conditions do you need a new or better truck? Why?

28. Do you have any trucking problems, or further comments on grain transportation?