A COST ANALYSIS OF TRANSFERRING GRAIN BY FARMER OWNED AND OPERATED TRUCKS

A Thesis

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ABSTRACT

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Proposed rail rationalization[1] and the rationalization that the present elevator system will likely undergo in the future warrant careful study. Rationalization will require some producers to haul their produce further to the sales outlets. The additional costs, to the farmer, in grain hauling must be considered in any rationalization program. The purpose of this study is to analyze trucking costs and to determine the average transfer costs in transferring grain to the sales outlet in farmer owned and operated trucks.

The data were obtained from a random sample of 200 Western Canadian farmers. The information collected for the study was for the 1967-68 crop year.

The procedure followed included an evaluation of the fixed costs, variable costs, dead-haul cost, and average total transfer costs. The average cost was compared with the generally accepted transfer cost, of 0.5 cents per bushel-mile, using a statistical test of differences between means.

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[1]Rationalization is the act of bringing an industry into accord with up to date methods of organization and operation.

Truck age, load size, hauling distance, annual mileage, and road surface were hypothesized to have significant effects on average transfer costs. The procedure used to determine their relationship to cost was a multiple regression. The regression model was also given to predict average total transfer cost for any given set of independent variables. Marginal costs were estimated for additional hauling distances on the basis of the computed average variable costs (excluding deadhaul costs) as determined in this study.

The major findings of this study are:

1. The average total cost of transferring farm grain to the sales outlet in farmer owned and operated trucks is significantly below the usually accepted 0.5 cents per bushel-mile. The estimate obtained in this study was 0.34 cents per bushel-mile.

2. The estimated additional bushel-mile cost (marginal cost) was 0.14 cents.

3. The average loading-unloading-waiting costs varied from a low of 54.45 cents per load for a one-half ton truck to 108.68 cents per load for a three ton truck with an average of 88.25 cents for all trucks.

4. The average speed travelled hauling grain was 31 miles per hour for the round trip.

5. The average labor cost for driving, maintenance, loading, waiting, and unloading was $1.72 per hour. Labor costs accounted for 42 percent of the average total cost of

hauling grain.

6. The average fuel cost was 2.35 cents per mile for an average of 0.026 cents per bushel-mile.

7. The hypotheses that the cost of hauling farm grain from the farm to the sales outlet would decrease in cents per bushel-mile as the load size, annual mileage, truck age, and hauling distance increased was supported by the sample under study.

8. The hypothesis that the cost of hauling farm grain from the farm to the sales outlet would decrease in cents per bushel-mile as the portion of paved roads travelled increased was not supported by the sample under study.

9. The ratios of various costs to total costs were: Fixed Costs 35 percent; Variable Costs (less dead-haul costs) 41 percent; and Dead-Haul Costs 24 percent.

10. The average cash outlay to transfer grain from the farm to the sales outlet, less interest and labor, was 0.09 cents per bushel-mile.

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CHAPTER I

INTRODUCTION

GENERAL PROBLEM

Historically,[1] the responsibility of transporting grain from the farm to the shipping point has rested with the producer. From the shipping point the railways delivered the grain to the port or domestic destination at the producer's expense. The railways agreed to haul grain in accordance with a fixed rate structure in return for considerations and financial aid received in the construction of a rail network much as it is today. The first trans-continental railway was completed in 1885. However, it was approximately ten years later before world prices rose sufficiently for the wheat industry to become of economic value in the export market. Although the railways were expected to be operated as an economically viable entity, much of the railway network of the West, as in the East, was built for political reasons: "to settle Canada's undeveloped agricultural land, exploit her minerals and lumber, and to direct the flow of Canadian trade throughout the length of the Dominion".[2]

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[1]For a more detailed history of the development of the Canadian Grain Industry refer to: V.C. Fowke, Canadian Agricultural Policy The Historical Pattern, (Toronto: The University of Toronto Press, 1946).

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

Toward the end of the nineteenth century, the movement of grain from farm storage facilities to rail was slow and difficult. In 1888, the monopoly granted to the CPR in 1880 was revoked, making competition possible among railway companies to open the Canadian Prairies. This resulted in a rail network of sufficient density that most farmers would have to travel no more than ten miles to a delivery point. It was only natural that elevators, hamlets, villages, and towns would spring up along these tracks as the prairies were settled.

By the 1930's the highway system and the motor carrier had developed to the extent that the railways no longer were able to enjoy a monopolistic position in freight movement. As competition from the motor carriers grew, and continues to grow, branch lines were found to carry a lower and decreasing relative volume of traffic. Facing this relative loss of traffic, the railways have first attempted to reduce service and eventually to withdraw it entirely and to abandon the uneconomic lines. Reasons for the extensive construction of branch lines on the prairies may have been a misjudgment of the uncertain potential which existed or it may have been a fear of competition. If one company were not to build a branch line, it may have been feared that another would and thus would capture some potentially valuable business. As a result, the railways have applied to the Canadian Transport Commission to have lines abandoned.

STATEMENT OF THE PROBLEM

If rail rationalization is forthcoming, there will necessarily be a general change in the farm delivery pattern. It is estimated[3] that the current applications for abandonment, if granted, would result in the reduction of 673.5 miles by the CPR and 844.3 miles by the CNR for a total of 1,517.8 miles in the three prairie provinces. The loss of the suggested 1,517.8 miles of track would necessitate the decrease of 233 elevators on the prairies - 26 in Manitoba, 162 in Saskatchewan, and 45 in Alberta. In terms of elevator capacity, a total of 13,553,300 bushels would be lost - 1,789,300 in Manitoba, 8,982,100 in Saskatchewan, and 2,781,900 in Alberta. It is inevitable that the distance between elevators will increase with rail rationalization, elevator rationalization, and the availability of the motor carrier. This increased distance between elevator points will mean longer hauling distances for the farmers which in turn may be reflected in higher trucking costs. To make effective use of the most economic and satisfactory method of delivering his grain to the consumer, the farmer must utilize the best combination of facilities at his disposal.

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[3]Data supplied by the North-West Line Elevator Association, December 18, 1969.

The argument put forth in defense of rail rationalization has its basic roots in the economic position of these branch lines which are claimed to be unable to carry their share of the costs. It is, therefore, necessary to determine comparable costs for the feasible alternatives for grain transportation in these areas. Research[4] has indicated that trucks are competitive with railways for short distances. However, "the statutory rail rates for grain and the nature of grain has prevented serious competition other than for very short distances".[5] At the present time there is no real agreement or adequate knowledge on the cost of grain transportation either by farm trucks or by commercial trucks. Concern[6] is evident in the variation of cost figures of moving grain with the expectation that attempts are made by those with vested interests to use a cost figure which would best support their cause.

Some studies have been done on the cost of transporting grain from the farm to the sales outlet. A Saskatchewan

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

[5]Report of the Royal Commission on Transportation, (Queen's Printer and Controller of Stationary: 1962), Vol. I, p. 48.

[6]Interviews with members of both the railway and elevator companies revealed that there was disagreement over suggested average grain hauling costs. The 0.50 cents per bushel-mile was not convincing when compared to their costs.

study[7] estimated the average trucking cost to be 0.50 cents per bushel-mile. This figure was supported by Young[8] when he estimated the average assembly cost to be 0.47 cents per bushel-mile in Manitoba. Since the average annual mileage per truck in Young's study was 2,924 it would appear that there was excess capacity which may be utilized by custom hauling. For this reason, the analysis on commercial trucking currently being done by Moore[9] may be relevant in determining whether or not a farmer should truck his own grain to the sales outlet or if he should make use of commercial facilities. Moore suggests that the commercial truckers charge less than 0.50 cents per bushel-mile, the estimated cost for farmers to haul their grain in their own trucks.

Riordan[10] derived variable costs for hauling grain by a one ton truck, hauling 100 bushels, according to road

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[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 Division), p. 2.

[8] K.B. Young, An Analysis of the Cost of Assembling Grain by Farm Trucks in Manitoba, (Winnipeg: Department of Agricultural Economics and Farm Management, University of Manitoba, Research Report No. 11, October, 1966), p. 99.

[9] G.W. Moore, "Cost Analysis of Assembling Grain by Commercial Trucks", (M.Sc. Thesis in progress, University of Manitoba, Winnipeg, 1970).

[10] E.B. Riordan, Spatial Competition and Division of Grain Receipts Between Country Elevators, (Unpublished M.Sc. Thesis, University of Manitoba, Winnipeg, February, 1965), p. 46.

surface. The per bushel-mile cost (excluding dead-haul)[11] was 0.13 cents on pavement, 0.16 cents on gravel, and 0.24 cents on earth.

With concern over the different cost figures used in various situations there is a need for a more extensive analysis than the previous Young study. An attempt should be made to choose a larger sample from an area representative of all conditions which may be found in the three prairie provinces. An accurate estimate of grain transportation costs by both farm trucks and commercial trucks is necessary.

OBJECTIVES

Assuming that the overall objective in grain transportation is to use the most efficient mode available, it is necessary to analyze the cost of transporting grain by truck to ascertain to what extent trucking may supplement, or replace the railway. The general objective of this study is to analyze the cost of transporting grain from the farm to the sales outlet[12] in farmer owned and operated trucks. The specific objectives of the study are:

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[11]"Dead-Haul" is defined as the labor costs for loading the truck, waiting at the elevator, and unloading the truck at the elevator.

[12]"Sales outlet" is defined as any place where grain is purchased commercially.

1. To estimate the average cost per bushel-mile[13] of delivering grain from the farm storage site to the sales outlet by farmer owned and operated trucks.

2. To determine the average cost per bushel-mile to deliver grain for various sizes of trucks, ages of trucks, road surfaces travelled on, annual mileages, and hauling distances.

3. To derive an equation to predict the average cost per bushel-mile to deliver grain by various sizes of trucks, ages of trucks, road surfaces, annual mileages, and hauling distances.

4. To derive implications from trucking costs for costs of branch line abandonment as related to farmers.

ASSUMPTIONS

The main assumptions made in this study to make the analysis possible include the following:

1. Each trip to the sales outlet was charged entirely to the hauling of grain. It was assumed that the farmer does no other business while in the process of hauling grain.

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[13] A "bushel-mile" is defined as the transferring of one bushel one mile. For the purpose of this analysis grain will be measured in terms of wheat equivalent. It is realized that the cost will vary with varying bushel weights for different grains.

2. The fixed and variable costs of the farm trucks were allocated to the hauling of grain as determined by the portion of the total annual miles travelled in the hauling of grain.

3. It was assumed that the data obtained from the farmers in the sample were an accurate account of trucking costs, and that the sample was representative of the population under study.

SCOPE AND PROCEDURE

This study is an extension of an earlier one, done by Young, which was confined to a small sample of Manitoba farmers delivering grain to a random sample of different elevators, in the neighborhood of Winnipeg, in the 1964-65 crop year. The extension of this study will include a sample drawn at random, following accepted statistical sampling procedures, from Manitoba and Saskatchewan. The study will be limited to the cost of transporting grain by farm trucks in Western Canada. The results of this study with the information on the cost of commercial trucking of grain; rail costs; optimum size, number and location of elevators; and policies affecting the grain industry will be used in future analyses of the rationalization of the total transportation and handling system of grain.

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in the output unit. Transporting one bushel 100 miles is different from transporting 100 bushels one mile although the bushel-miles are 100 in both cases.

This study differs somewhat from Riordan's in that the specific interest in this study lies in the unit transfer cost for a specific commodity. Riordan was concerned with a cost to move a load a single mile with special efforts to differentiate the costs based on road surface. Young's objectives were more in agreement with those of the current study although some variables which seem significant to the analysis were omitted in the former study. In addition to the variables considered by Young, this analysis will take into account the effect of annual mileages, road surface, and age of truck on trucking costs. In addition, a housing cost will be determined.

The procedure in this study will involve the calculation of the components of total costs such as fixed costs, variable costs exclusive of dead-haul, and dead-haul costs in an attempt to estimate the average costs for all trucks and for several stratifications deemed desirable. The stratifications will include age, annual miles travelled, and size of truck.

The methods used in testing the hypotheses[14] outlined in Chapter II of the study include a test of significance between means in the case of Hypothesis 1, and a multiple regression analysis in the cases of Hypotheses 2 to 6. The regression function derived to test the aforementioned hypotheses will be used to predict transfer costs per bushel-mile given a set of independent variables.

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[14]Outlined on Page 23.

ORGANIZATION OF THE STUDY

Chapter II will set out the theoretical, conceptual, and statistical model used in this study. Chapter III will follow with a discussion on the data requirements, and specific costs. This will be followed by the empirical results in Chapter IV and the economic implications and conclusion in Chapter V.

CHAPTER II

THEORETICAL ASPECTS OF TRANSPORTATION COSTS WITH SPECIAL REFERENCE TO TRUCKING COSTS

GENERAL COST STRUCTURE

The relevant economic theory and the conceptual model used in the analysis will be discussed in this chapter. The main topics include the theoretical cost structure, assumed truck cost structure, and the theoretical model.

Theoretical Concepts

Short run transportation costs may be divided into two broad categories, which, when added together, make up total costs. Fixed costs are those costs which are incurred regardless of the size of output. Variable costs are the costs of all factors of production whose quantities may be changed in the short run.

The economic concept of the short run period is that length of time through which some factors are fixed and are not subject to adjustment. In the short run, the firm must cover all variable costs but need not cover all fixed costs to stay in business. In the long run, all costs become variable and must be covered for the firm to remain in operation. Farm truckers, at the time of decision making, will plan to cover all costs. In a trucking cost analysis, as in this study, where one crop year is being analyzed, the short run must be considered. Thus, the cost structure will include both fixed costs and variable costs.

Fixed costs may be divided into two categories; first, the single outlay costs; and secondly, those costs which are of a recurring nature. The former includes depreciation of the truck and the interest on the investment in the truck. The latter includes the annual licence fee and insurance costs necessary to enable the vehicle to be operated in the year for which these fees apply. The sum of the costs will be distributed over the entire output, and thus the greater the output, the smaller the average fixed costs. Variable costs will depend on the magnitude of the output. These costs include such items as fuel, repairs, lubrication, maintenance, utilities, and wages.

Theoretically, the short run average and the short run marginal cost curves are "U" shaped as shown in Figure II-1. The shape of the marginal cost curve is determined by the shape of the total variable cost, since fixed costs remain constant regardless of the output level.

TRUCKING COST STRUCTURE

Trucking Cost Concepts

It is suggested by Young and Moore that the conventional concept of "U" shaped average and marginal costs do not typify the short run cost structure of trucks. The variable costs may be divided into two categories. The dead-haul costs are labor costs and this author has chosen to separate this cost from the variable costs of trucking. Once the decision is made to make the journey, the dead-haul cost acts in the same manner as the fixed costs with the average dead-haul decreasing as the hauling distance increases. The second category of variable costs are the conventional variable costs which vary with levels of output. In the long run, one may argue that as the age of the trucks increase and as the total mileages increase the average variable cost will increase. In general, however, farm trucks may be assumed to accumulate relatively low mileages over the period of ownership. For the purpose of this study, it is assumed that there is a uniform level of intensification in the rate of hauling grain and increased usage of the truck becomes a time dimension. Thus, it may be assumed that the variable costs for travelling any one mile should be no different from that of any other mile given the same travelling conditions. For any given hauling distance, the average dead-haul cost per bushel-mile will be constant; but the magnitude will vary with the average hauling distance. The average fixed cost is assumed, as in conventional theory, to decrease as the costs are divided over a greater number of output units. The summation of the constant average variable costs and the decreasing average fixed costs give a downward sloping average total cost as illustrated in Figure II-2.

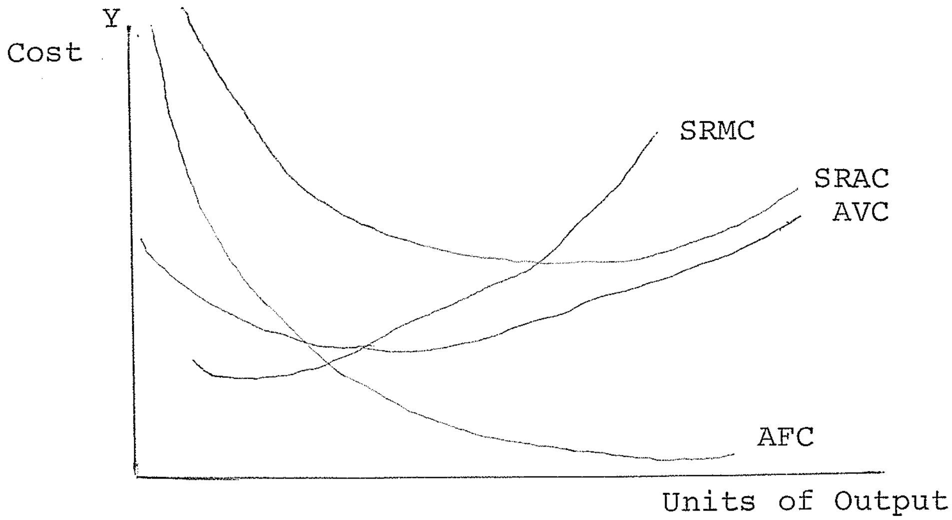

Figure II-1

Theoretical Short Run Cost Curves

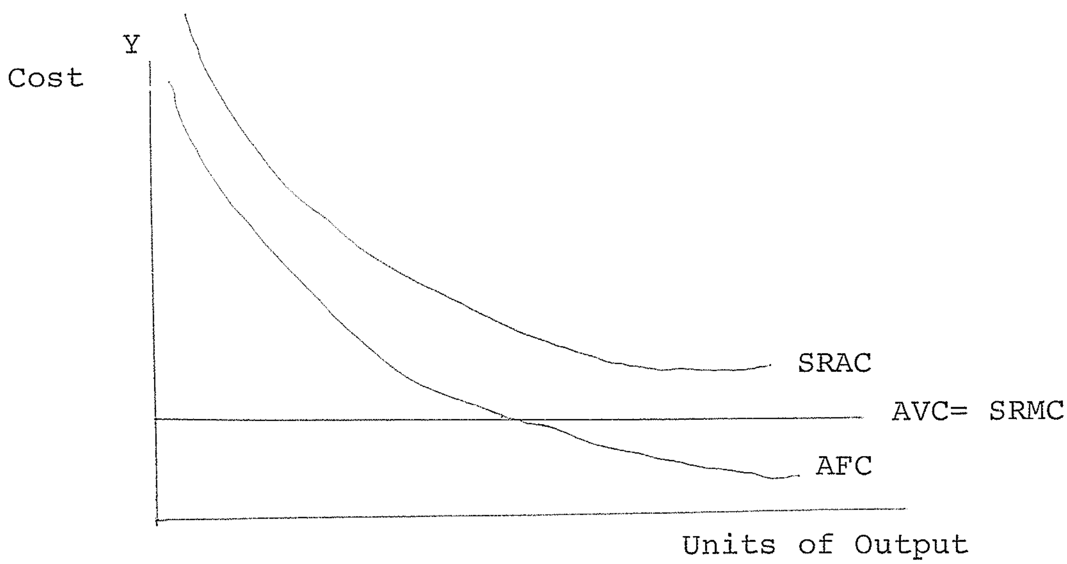

Figure II-2

Assumed Truck Short Run Cost Curves

Effects of Weight and Distance on Trucking Costs

One of the major conceptual problems in transportation costs is the heterogeneity of the output unit and what the output unit should be. Even in the hauling of grain, where the output unit is taken to be a bushel-mile, there are variations in the sizes of trucks, the hauling distances, and the speed at which the trip is made. "For any particular distance, total cost per shipment rises less than proportionately as the weight increases. With both distance and weight increments, however, the increase in cost is less than proportionate. Consequently, we find that the average cost per ton-mile per shipment declines as tons and/or miles increase".[1] Wilson[2] argues that there may be distinct economies for trucks up to one thousand or more miles, after which the marginal decrease in cost seems insignificant. The distance - weight - cost relationships may be shown in a three dimension graph as depicted in Figure II-3.

This figure is a graphic presentation which attempts to show the plane of variable costs per shipment where total costs rise throughout but increase more significantly as the

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[1] G.W. Wilson, Essays on Some Unsettled Questions In The Economics of Transportation, (Bloomington: Foundation for Economic and Business Studies, Indiana University, Indiana Business Report No. 42, 1962), p. 58.

[2] Ibid., p. 59.

weight increases than as the distance increases. To determine the relationship between distance and weight, isocosts may also be constructed as in Figure II-4.

The lack of symmetry in the diagram indicates that total costs rise more rapidly with weight than with distance. Various combinations of weight and distances may be used to derive equal costs as are shown by the isocost curves. The cost behavior with respect to weight and distance may be shown on separate diagrams in which one of the variables is held constant as in Figures II-5 and II-6.

Truck Utilization

In looking at the average cost of transferring grain by farm trucks, it may be assumed that farm trucks are not used to their capacity and are operating on the decreasing portion of the average total cost curve. Since the average variable and average fixed costs are constant and decline respectively, it follows that the average total cost declines. If the annual miles, or the annual bushel-miles, were less than the minimum optimum scale, increased usage of the truck would tend to reduce the average fixed costs, and thereby reduce the average unit cost. In conventional theory this reduction may continue until the decrease in average fixed costs is offset by increases in the average variable costs, which would be beyond the output range relative to farm trucks.

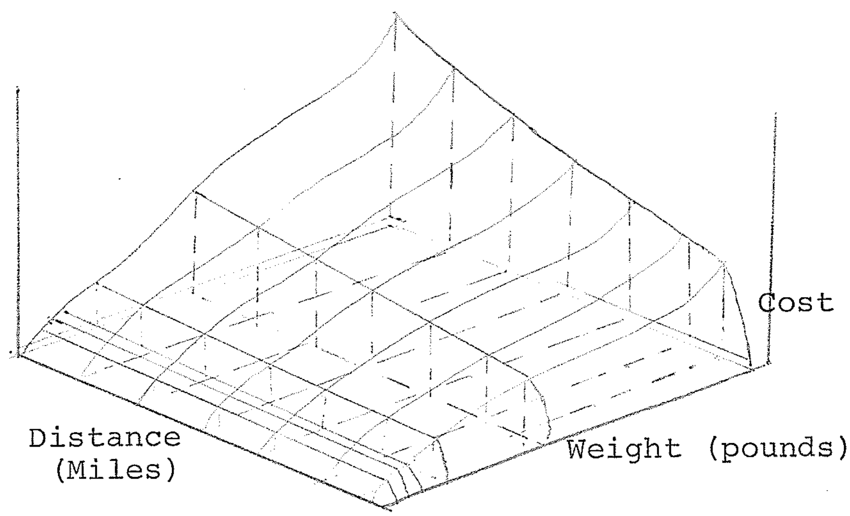

Figure II-3

Cost Behavior in Transport With Varying Combinations
Of Weight and Distance

Source: G.W. Wilson, Essays On Some Unsettled Questions In The Economics of Transportation, (Foundation for Economic and Business Studies, Indiana University, Indiana Business Report No. 42, 1962), p. 60.

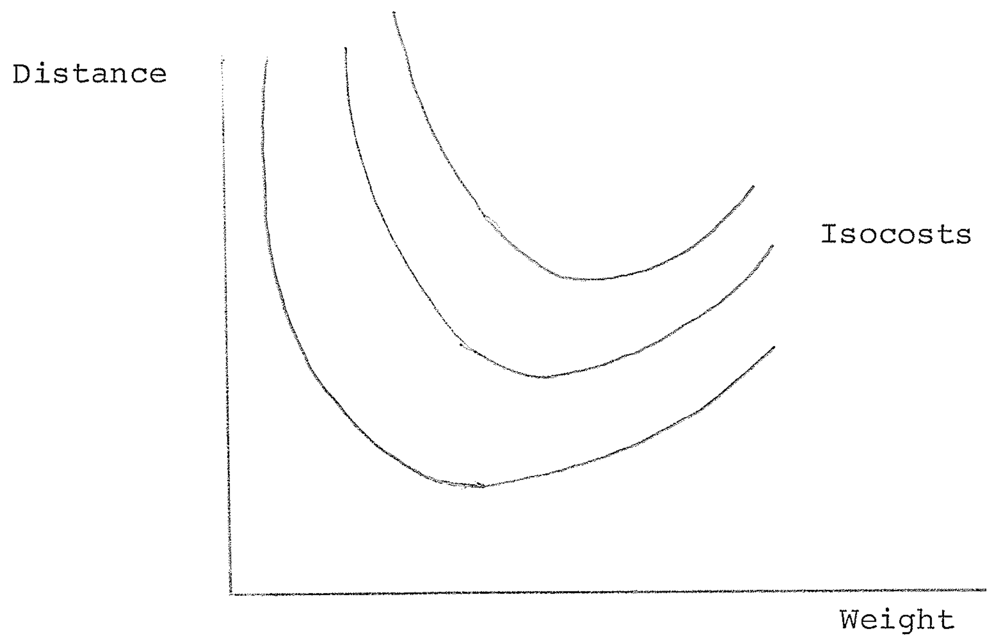

Figure II-4

Distance - Weight Cost Curves

Source: G.W. Wilson, Essays On Some Unsettled Questions In The Economics of Transportation, (Foundation for Economic and Business Studies, Indiana University, Indiana Business Report No. 42, 1962), p. 61.

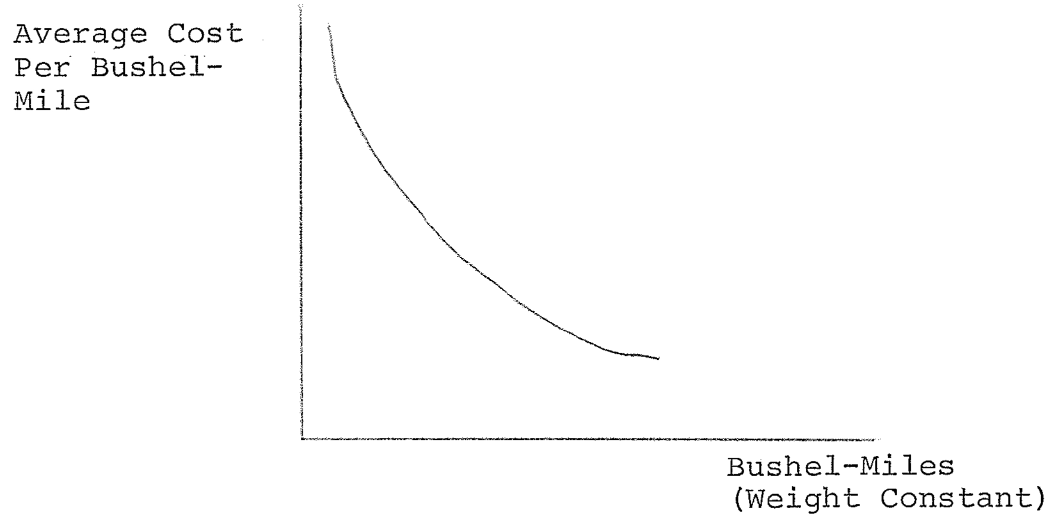

Figure II-5

Cost Behavior With Respect To Weight (Weight Constant)

Source: G.W. Wilson, _Essays On Some Unsettled Questions In The Economics of Transportation_, (Foundation for Economic and Business Studies, Indiana University, Indiana Business Report No. 42, 1962), p. 62.

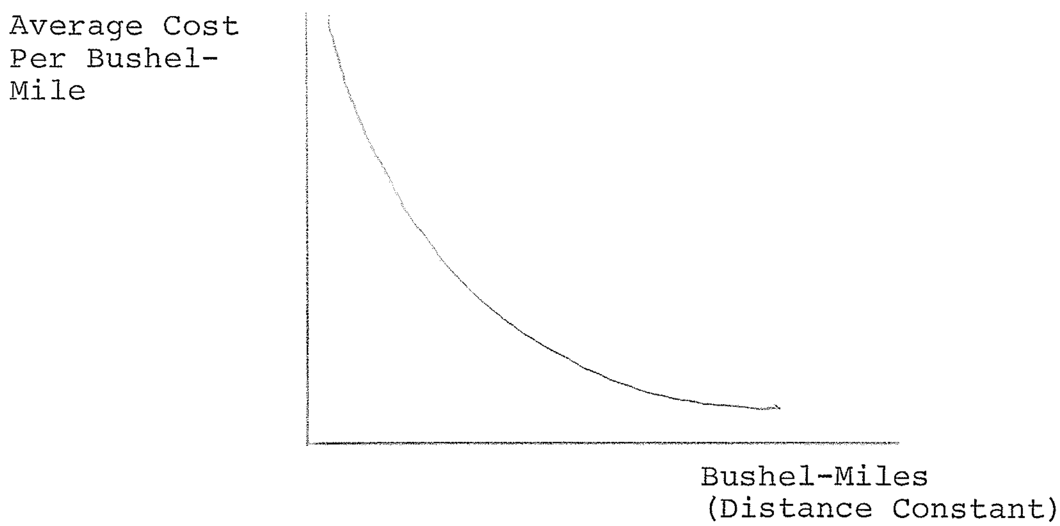

Figure II-6

Cost Behavior With Respect To Distance (Distance Constant)

Source: G.W. Wilson, _Essays On Some Unsettled Questions In The Economics of Transportation_, (Foundation for Economic and Business Studies, Indiana University, Indiana Business Report No. 42, 1962), p. 63.

The size of the truck may have considerable influence on the utilization of the vehicle. The size must be considered with the hauling distance, with the volume to be hauled, as well as with the degree of flexibility required in the farm operation. For any given level of output utilization of the vehicle would vary inversely with the size of the truck. Figure II-7 gives a theoretical geometric description of two sizes of trucks showing the cost relationship in average variable costs as volume increases with a given hauling distance. As shown in Figure II-7, the two trucks of different sizes have unequal load capacities. The one ton truck has a capacity of 100 bushels while the three ton truck has a capacity of 250 bushels. Although the major part of the variable cost may result because the journey is made, it is reasonable to assume that the average variable cost per output unit would decrease as the load size increased, on a per load basis. The cost function is discontinuous because each truck has a maximum capacity and any partial load would require an additional trip. A trip with less than a full load would result in higher than minimum average costs per bushel-mile. The discontinuity in the cost function occurs where an additional trip is required in addition to a full load. Figure II-7 indicates, theoretically, where the average variable costs for each of the two trucks is lowest. At less than 100 bushels, the one ton truck has the lower average variable costs per bushel-mile. However, for any load over 100 bushels, the three ton truck has

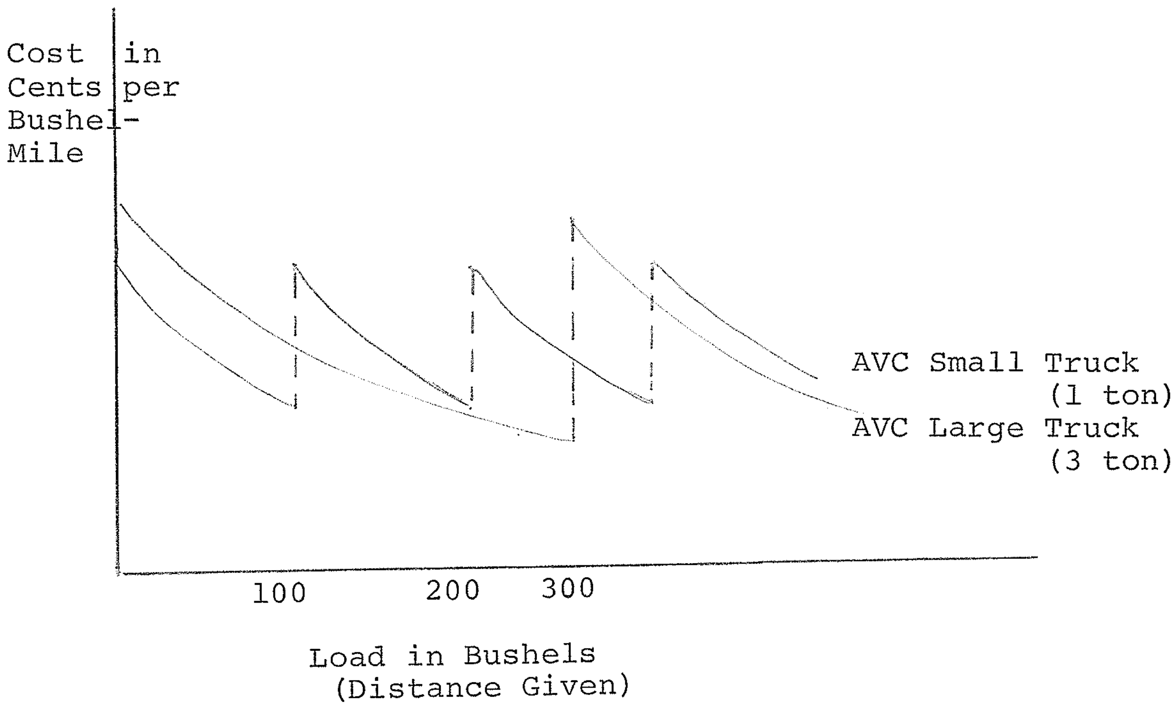

Figure II-7

Theoretical Cost Relationship as Volume Increases
For Different Sizes of Trucks

the lower average variable costs. Theoretically, different sizes of trucks may have advantages over certain ranges of loads and distances.

CONCEPTUAL MODEL

The basic conceptual model used in the study will be similar to that used by Young. However, the review of literature[3] left questions unanswered and queries arose with respect to some procedures used in previous studies. For example, previous studies have concluded that the size of the load, the length of haul, and the road surface play an important role in determining the final transfer costs of hauling grain. Also, there appears to be little information with respect to the impact of the age of the truck as well as the annual number of miles travelled on the cost of hauling grain.

It can be argued that as the age of the truck increases, its value decreases resulting in lower depreciation and interest on investment. When the reduced fixed costs are averaged over the miles travelled, the average fixed costs will be lower and should be reflected in the average fixed cost of hauling grain. Similarly, when the number of miles per period increases, average fixed costs per unit of output

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[3]A brief literature review may be seen in Appendix A.

will decrease. These two aspects were introduced into this study in addition to size of load, length of haul, and road surface, which have been analyzed in previous studies.

The specific hypotheses made in this study were as follows:

1. The average cost of transferring prairie grain to the sales outlet by farmer owned and operated trucks was 0.50 cents per bushel-mile. The alternate hypothesis was that the average cost was less than 0.50 cents.

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

3. The average cost per bushel-mile decreased with increased hauling distances.

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 portion of non-paved roads travelled increased.

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

To derive a quantitative relationship between the dependent and the independent variables the linear model;

$$Y = B_o + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + \varepsilon$$

was postulated where:

Y = cost in cents per bushel-mile

B_o = constant

B_i = regression coefficients ($i = 1, 2, \ldots, 5$)

X_1= miles in 000's travelled in the 1967-68 crop year

X_2= one-way hauling distance (miles)

X_3= load size (bushels)

X_4= percentage of non-paved roads

X_5= age of truck

ε = random error

It was hypothesized that B_i (i = 1, 2, 3, 5) were less than 0 and B_4 was greater than 0.

The conceptual model will be fitted to both the actual data and the logarithmic transformation of the data, and the form yielding the best fit will be used to test the hypotheses regarding the regression coefficients. In addition, the same model will be used as a predictive equation, such that trucking costs (Y) may be estimated for a given set of independent variables.

CHAPTER III

EMPIRICAL PROCEDURE

This chapter will cover three main areas. The first part will outline the data required. The second part will be a discussion on the determination of the specific costs, and the third part will outline the determination of the grain hauling costs in cents per bushel-mile.

DATA REQUIREMENT

The data[1] required in determining the grain hauling costs include all the components of both the fixed and variable costs. The fixed costs include depreciation, interest on investment, licence fees, and insurance costs. The variable costs include the costs for lubrication, repairs, tires and batteries, utilities, fuel, and driver labor. Also, the dead-haul cost was required.

The total annual miles travelled by the trucks were required, as were the average loads carried and the distance the grain was hauled to the sales outlet. The amount of grain transported to the sales outlet was also required. From this data, the number of miles the truck was used to haul the grain was calculated.

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[1]See Appendix B for sample characteristics and Appendix D for the questionnaire used in obtaining the data.

DETERMINATION OF SPECIFIC COSTS

Fixed Costs

Depreciation. In general, depreciation should be charged as a fixed cost; that is that portion of value decrease which may not be attributed to truck use. One must agree that part of the reduced value is a result of usage and not entirely due to ownership and the passage of time. It, however, is virtually impossible to determine that portion which should be a variable cost; therefore, the entire depreciation has been considered as a fixed cost.

Capital assets, such as trucks are purchased at one period in time with the expectations that they will be utilized over a number of periods. Since the value of these vehicles decreases with age, usage, and obsolescence, one expects that eventually at some time in the future that that vehicle must be replaced. Since its value or usefulness will be consumed over a number of periods, the cost of the slowly-using-up of the assets must be distributed over the periods. As the age of the truck increases, its reliability may, or may not, be impaired depending on the manner in which it was maintained and the job it is expected to perform. As a result, it becomes very difficult to allocate the cost of owning a truck in the proper proportion over a number of periods.

There are several ways of computing depreciation, all of which have advantages and disadvantages. For the purpose of this study three methods, the annual revaluation, the straight-line, and the diminishing balance methods were considered.

The annual revaluation consists of revaluating the asset for each time period with the difference between two consecutive periods being the depreciation. This method attempts to establish the market value of the asset for each year. Fluctuations in economic conditions may bring about fluctuating prices over time, and therefore, an irregular pattern in depreciation. Applied to farm trucks, annual revaluation is unsatisfactory. Depreciation arrived at in this manner during the first few years of use of the truck diminishes sharply because there is, at first, a rapid loss in resale value. However, as stated earlier, trucks are purchased to be used by the farmer for a long period of time, and resale is not intended. Therefore, resale value is of little significance. Also, as the truck's age increases, any change in resale value, becomes increasingly difficult to perceive. Changes in the resale value of trucks are likely to be caused as much by changes in farm business outlook or in the price level of farm trucks as by diminishing usefulness of the truck.

The straight-line method consists of dividing the total anticipated depreciation by the number of years the asset is expected to last to find the annual depreciation. The total depreciation is the purchase price minus the salvage value. This method works well for analyzing the truck business when the truck is used a rather constant amount throughout the years.

It does not, however, reflect the market value, especially in the early years of the asset's life.

The diminishing balance method appears to conform closely to the decline in the resale value. Using this method, a percentage of the remaining value is deducted each year for depreciation. There may be some disagreement over the rate of discount used in this method making its use somewhat difficult when the life span of the asset is unknown. A constant percentage of the diminishing balance results in a depreciation each year which is smaller than that of the preceding year. The resale value may decline substantially the first year of use but it is unreasonable to charge as much as 20 or 30 percent of the purchase price as depreciation when the truck is expected to last in excess of 10 years. However, there is little relationship between this depreciation and the performance of the vehicle. Again, the truck was obtained for use; not for resale.

Each of the aforementioned methods has merits and demerits. Since it was assumed that most farm trucks are not purchased new, the new price would be unknown, and since the useful life of trucks, also, is unknown, and since farm trucks are not purchased for resale, some method of determining depreciation other than any of those discussed must be used. The method used was a combination of the straight-line and annual revaluation methods. The method chosen, was to determine the total depreciation of the truck, while owned by the farmer, based on the purchase price, [to the farmer], minus the current resale value, and to assign that depreciation equally to each and every year over which the farmer owned the truck.

Interest on Investment. Each farmer who owns a capital asset has had to make arrangements for the payment of the principal involved. Should the asset be financed or the money borrowed externally, there is an interest charge which must be assigned as a cost of owning that asset. This charge will be incurred whether or not the asset is utilized. Therefore, this charge will be assigned as a fixed cost. Should the principal be paid from funds within the firm, there arises an opportunity cost for the use of that money. Had it not been used to purchase the specific asset, it may have been utilized elsewhere either within or outside the firm and would effect an additional return to the firm. Thus a charge must be assigned for the use of the capital invested. The rate of interest charged should closely approximate that which the owner could earn on the same capital had it been invested in a safe investment for an intermediate period of time. As many farmers do not have full equity to their trucks, the rate of seven percent, one percent above the return on a safe investment, has been used as a return to truck investment.

The beginning and end of year values were averaged to give an average capital investment for the period. The interest charged was then calculated on the average investment at a rate of seven percent. To acquire the average interest on investment, the sum of the interest assessed was averaged over the number of trucks in the group. The per mile interest charges were calculated by averaging the average interest charge over the average number of miles travelled by the group of trucks in the 1967-68 crop year.

Housing Costs. Controversy has come to the forefront in the discussion on housing costs assigned to farm trucks. Analyses vary from that of Furniss[4] who assigned a charge of 0.5 percent of truck replacement value for housing costs in his computations to that of Young who claimed that the proportion of trucks housed was too small to warrant a housing cost assessment. Young[5] suggests there is a question as to whether it is economically rational to house farm trucks.

Since many farm trucks are housed, a housing cost was calculated. This cost was not used in the analysis, but was computed as a supplementary cost and may be added to the average trucking costs when deemed desirable.

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[4]I.F. Furniss, Cost Accounting for Agriculture, Part 1, (Illustration Station Division, Canadian Department of Agriculture, February, 1958), p. 6.

[5]K.B. Young, op. cit., p. 42.

The value of the building and the portion used to house the truck were obtained from the survey, and thus, a housing value could be established. It was assumed that the depreciation rate should be five percent of the value of the housing facilities. The interest on the housing facilities was determined by finding the average investment for the period and charging six percent. It was assumed that the opportunity cost for fixed capital assets such as buildings, should be six percent which is one percent less than that used to calculate the interest charges for trucks.

Licences. Licence fees[6] are an annually recurring cost based on the gross tonnage of the truck and the type of service provided, and are considered, therefore, as fixed costs. Farm trucks, although in the same licence category, will have varying licence fees depending on the tonnage hauled. Licence fees were accepted as reported in the survey.

Insurance. Insurance charges for farm trucks are costs which have no relationship to the usage of the unit and are based upon a specific coverage, and thus are a fixed cost. The insurance costs were used as obtained from the survey. The per mile insurance cost was calculated in the same manner as that for licence costs.

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[6]The licence cost, in terms of cents per mile, was calculated by weighing the average licence cost for the group of trucks by the average annual mileage of that group.

Variable Costs

Lubrication. It is assumed that the lubrication cost was directly related to the miles travelled and therefore, a variable cost. Although the farmers, in general, used bulk oil in their trucks they knew the price paid for oil, filters, and grease, the distance travelled on an oil change and the oil consumption; consequently, they were able to give a reliable lubrication cost even though oil changes were made on the farm and no specific records were kept for each oil change. The lubrication cost per mile was calculated in the same manner as were licence fees.

Repairs. Repair costs like those of lubrication are related to usage, but are also related to management and maintenance practices. In general, repairs may be considered a result of usage and therefore, may be assumed to be a variable cost and for the purpose of this study will be regarded as such. Although repairs will be regarded as a variable cost, it is realized that these costs occur sporadically over the life of the truck and will not fall evenly into each and every time period even though the yearly mileages may be approximately the same. A major repair, such as a engine, may be the result of an accumulated number of miles and there may be some arguments to depreciate that repair over a number of years and thus assume it to be a fixed cost. It is very similar to depreciation in which a charge is made to cover obsolescence and age, but it, at the same time, cannot be separated from the decreased value due to usage.

For the purpose of this study, it was assumed that with the given sample the sum of the repair cost to each group of trucks averaged over the number of trucks in the group would give the best estimate of the average yearly repair costs for the various groups considered. The average repair costs were then averaged over the average number of miles driven to give an average per mile repair cost.

Batteries and Tires. Batteries and tires are variable costs because of their nearly direct relationship with miles travelled. Estimates made by Casavant and Nelson[7] indicated that the median and modal estimates of tire life on commercial trucks to be 100,000 miles. This estimate would indicate that the average farm truck with its low annual mileage may never require additional tires in its lifetime. This, however, may not be the case since a farm truck travels much of its mileage on gravel and unimproved roads where tire hazards are high. Further, the effect of aging and weathering may be more detrimental to farm trucks than the actual miles logged. Batteries may be considered in the same category as tires, since age and usage will determine the length of battery life.

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

For the purpose of this study it was assumed that the tire and battery costs would be the weighted averages of the costs reported by the truck owners. The average cost was weighted by the number of trucks and the average annual mileages to give a per mile tire and battery cost for each truck stratification. It was realized that some trucks had no tire and battery costs charged to the 1967-68 crop year even though there were tire and battery depletion due to usage. In addition, some trucks reported high costs which may have been due to usage in other periods.

Utilities. Considerable argument may arise over the placement of utilities into either the fixed or variable cost category. That portion of the hydro, telephone and heat bill which must be paid regardless of truck usage and can be assigned to the truck may be regarded as a fixed cost, whereas that portion directly related to output should be considered a variable cost. When looking at farm trucks, the privilege of being able to use the utility may be a fixed cost, but, considering the minute portion that would be of the minimum utility charge it may be ignored. The portion of the utility bills then charged to the truck for actual usage of that utility may be charged as a variable cost. Farmers normally plug in the truck prior to usage; therefore, that cost may be charged over the number of starts. Although the cost is not directly related to mileage, it is directly related to usage.

Although there was no charge to telephone reported in the survey, hydro was used. To determine the cost of utilities, the sum of the utility costs as reported by the farmers, was averaged over the number of trucks in the group and then averaged over the average mileage accumulated by the group in the 1967-68 crop year. Some trucks were not used in the winter and thus reported no utility cost but they were averaged with those which did to get an average cost.

Fuel. One of the costs which is directly proportional to mileage travelled is that of fuel. The farmers were asked to estimate the average mileage obtained in the trucking of grain from the storage site to the sales outlet as well as the price paid for gasoline. The average gasoline costs per mile was determined by dividing the average gasoline price by the average miles per gallon obtained by the trucks.

Labor. In analyzing the cost of trucking, there must be a charge to labor to cover three areas of work done; repair and maintenance, driving time, and the time spent loading, waiting and unloading. Farmers do not consider their time in farm work, but for the purpose of this study a labor cost was used. It is assumed that while not hauling grain the farmer will be doing some other task. Since the area under study was large and covers areas which represent all types of farming from livestock to grain, it was assumed that no one area or single study could present a wage rate representative of the whole. To overcome that difficulty each farmer was asked what it would cost him to hire someone, on an hourly basis, to drive his truck or what he could earn doing similar work for someone else. The average was taken of those values given and that value was assumed to be the labor cost for the study.

A charge was made to the truck for repairing and maintenance in accordance with the calculated labor cost and the reported time spent in doing the task. The labor time was converted to a dollar value and then to a cost on a per mile basis.

To determine a labor cost for driving the truck, the average speeds driven by the groups of trucks were calculated. The time required to drive a mile was converted into a cost per mile by dividing the labor cost per hour by the average speed travelled.

Dead-haul. A labor cost for loading the truck, waiting at the sales outlet, and unloading the truck was also calculated. The average time for each process was summed to give the dead-haul time. This time was converted, at the hourly labor cost, into a dead-haul cost. To find a loaded per mile cost of the dead-haul, the cost was distributed evenly over the average number of miles on a one-way trip.

AVERAGE TRUCKING COST PER BUSHEL-MILE

In addition to the cost figures required in determining an average cost per bushel-mile, the average hauling distance as well as the average size of the loads carried were necessary. Assuming that there is very little grain being transported to the sales outlet from sites other than that of the farm yard, one may conclude that the cost of hauling grain one mile includes one mile under load and one mile empty. To determine the average trucking cost per bushel-mile, the cost of travelling two miles was averaged over the number of bushels in the load and added to the dead-haul cost which was averaged over the number of bushels in the load and the hauling distance.

The average additional cost of hauling grain increased distances to sales outlets, may be determined by calculating the average variable cost per bushel-mile. The distance of hauling should have no effect on the dead-haul costs per load if adequate elevator facilities are available, such that queuing time does not increase; thus, the additional costs for increased distances may be assumed to be the increased variable costs.

CHAPTER IV

EMPIRICAL RESULTS

This chapter will be concerned primarily with the empirical results obtained in this study. It will be divided into three parts: a presentation of the cost analysis, a summary of the regression analysis, and a comparison with the results of other studies.

COST ANALYSIS

Fixed Costs

The average fixed cost for the entire 142 trucks, as indicated in Table IV-1, was 10.30 cents per mile. The range was from 4.12 cents for the one-half ton trucks to 14.00 cents for the two ton trucks. The most important element was depreciation, accounting for an average of 5.52 cents or slightly more than 50 percent of the total fixed cost. The range was from 2.44 cents for the one-half ton trucks to 7.33 cents for the three ton trucks. The second most important element in the fixed costs was interest on investment which averaged 2.90 cents per mile and ranged from 0.86 cents for the one-half ton trucks to 4.05 cents for the two ton trucks. Licence and insurance costs were of lesser significance than the two aforementioned elements, with the average costs being 1.15 and 0.73 cents per mile respectively. The ranges were from 0.36 and 0.46 for the one-half ton trucks to 2.05 and 1.03

TABLE IV-1

AVERAGE FIXED COST IN CENTS PER MILE OF TRUCK OPERATION

Size of Truck	No. in Sample	Depreciation	Interest on Investment	Licence	Insurance	Average Fixed Cost
1/2	8	2.44	0.86	0.36	0.46	4.12
3/4	5	4.44	1.73	0.35	0.37	6.89
1	51	3.88	1.84	0.72	0.66	7.10
2	35	6.88	4.05	2.05	1.03	14.01
3	43	7.33	4.04	1.48	0.79	13.64
All	142	5.52	2.90	1.15	0.73	10.30

cents for the two ton trucks. The reason suggested for the higher average fixed costs for the two ton trucks than for the three ton trucks is that the average mileage for the two ton trucks was 2,216 as compared to 3,986 for the three ton trucks.

Variable Costs

The variable costs, exclusive of dead-haul costs, varied from 7.99 cents per mile for the three-quarter ton trucks, to 13.52 cents per mile for the three ton trucks with the average for all trucks being 12.27 cents per mile as shown in Table IV-2. The average lubrication cost was 0.58 cents per mile but varied from 0.45 cents per mile for the one-half ton trucks to 0.72 cents per mile for the two ton trucks. Repair expenditures were higher for two ton trucks at 2.52 cents per mile as compared to a low of 0.16 cents per mile for the three-quarter trucks and the average of 1.67 cents per mile. The average tire and battery cost was 1.67 cents per mile with the three ton trucks being the high at 2.34 cents per mile and the three-quarter ton trucks the low at 0.60 cents per mile. Utility costs varied from a high of 0.11 cents per mile for both the one-half and the two ton trucks while the three-quarter ton trucks were low at 0.06 cents per mile. The average for all trucks was 0.10 cents per mile. Labor for repairs varied from a high of 0.47 cents per mile for the two ton trucks to 0.29 cents per mile for the three ton trucks with the overall average being 0.37 cents

TABLE IV-2

AVERAGE VARIABLE COST IN CENTS PER MILE OF TRUCK OPERATION

Size of Truck	No. in Sample	Lubrication	Repairs	Tires & Bat.	Utilities	Repair Labor	Fuel	Driver Labor	Average Variable Cost
1/2	8	0.45	0.83	1.01	0.11	0.39	1.45	5.98	10.24
3/4	5	0.47	0.16	0.60	0.06	0.33	1.76	5.21	7.99
1	51	0.56	1.97	1.33	0.10	0.29	2.07	5.64	11.96
2	35	0.72	2.52	1.54	0.11	0.47	2.61	5.24	13.22
3	43	0.63	1.40	2.34	0.09	0.40	3.08	5.60	13.52
All	142	0.58	1.67	1.67	0.10	0.37	2.35	5.52	12.27

per mile. Fuel costs ranged from 3.08 cents per mile for the three ton trucks to 1.45 cents per mile for the one-half ton trucks. The average for all trucks was 2.35 cents per mile. There was not much variation in the driving costs among the trucks. The average was 5.52 cents per mile.

The repairs and repair labor costs appeared to be low for the three-quarter ton trucks and high for the two ton trucks relative to the other trucks. The reason for this variation may be that the two ton trucks were overloaded while the three-quarter ton trucks, which had limited use in hauling grain, were underloaded.

Dead-Haul Costs

Table IV-3 outlines the dead-haul costs, per load, for each size of truck. The average dead-haul cost was 88.25 cents per load while the range was from 54.45 cents for the one-half ton trucks to 108.68 cents for the three ton trucks. The dead-haul costs, per load, increased as the size of the truck increased with one exception. The three-quarter ton truck cost was greater than the one ton truck cost. It may not be assumed that the dead-haul costs per load are the same for all sizes of trucks.

Total Cost of Hauling Grain

The total costs, shown in Table IV-4, indicate that the average cost of hauling grain decreases as the size of the truck increases. The average cost was 0.34 cents per

TABLE IV-3

THE DEAD-HAUL COSTS PER LOAD FOR
VARIOUS SIZES OF TRUCKS

Size of Trucks	No. of Trucks	Dead-Haul Cost Cents Per Load
1/2	8	54.45
3/4	5	87.13
1	51	76.60
2	35	91.34
3	43	108.68
All	142	88.25

bushel-mile. The one-half ton trucks had the higher cost of 0.71 cents per bushel-mile while the three ton trucks had the lower cost of 0.26 cents per bushel-mile. The load size ranged from 52 bushels for the one-half ton trucks to 271 bushels for the three ton trucks. The average load size for all 142 trucks was 174 bushels. The average hauling distance was 6.27 miles, and the average annual mileage travelled by the trucks, for the 1967-68 crop year, was 3,415.

In addition to the trucking cost analysis, the housing cost was determined and is given in Table IV-5. The housing costs may be added to the trucking costs if deemed desirable. The cost of 2.37 cents per load was based on the 66 trucks which were housed. The housing cost ranged from 0.01 cents per bushel-mile for the three ton trucks to 0.05 cents per bushel-mile for the one-half ton trucks. The average cost was 0.01 cents per bushel-mile.

In Table IV-6, the cost components, of grain transfer costs, are shown as a percentage of the total transfer cost for the overall average of the 142 trucks analyzed. Fixed costs represented 34.80 percent, with variable costs, exclusive of dead-haul costs, at 41.44 percent, and the dead-haul cost at 23.76 percent. The cost to labor for both the dead-haul and driving time accounted for 42.42 percent of the

TABLE IV-4

AVERAGE TOTAL COSTS IN CENTS PER BUSHEL-MILE

Size of Truck	No. in Sample	Hauling Distance (Miles)	Load Size (Bushels)	Average Fixed Cost per Mile	Average Variable Cost per Mile	Dead-Haul Cost per Load	Average Cost in Cents per Bushel-Mile
1/2	8	6.69	52.00	4.12	10.24	54.45	0.71
3/4	5	3.40	85.00	6.89	7.99	87.12	0.65
1	51	5.71	106.19	7.10	11.96	76.60	0.49
2	35	7.32	195.00	14.01	13.22	91.34	0.34
3	43	6.35	271.28	13.64	13.52	108.68	0.26
All	142	6.27	174.27	10.30	12.27	88.25	0.34

TABLE IV-5

HOUSING COSTS IN CENTS PER BUSHEL-MILE

Size of Truck	Housing Cost in Cents per Bushel-Mile
1/2	0.05
3/4	0.03
1	0.02
2	0.01
3	0.01
All	0.01

TABLE IV-6

COMPONENTS OF GRAIN ASSEMBLY COST AS A PERCENT OF THE AVERAGE COST OF 0.34 CENTS PER BUSHEL-MILE FOR ALL 142 TRUCKS OF THE 1967-68 SAMPLE

Source	Percent of Total Average Cost		
Fixed Costs			
Depreciation	18.66		
Interest on Investment	9.80		
Licence	3.88		
Insurance	2.47	34.80	
Variable Costs			
Lubrication	1.98		
Repairs	5.64		
Tires and Batteries	5.63		
Utilities	.32		
Maintenance and Repair Labor	1.25		
Gasoline	7.95		
Driving Labor	18.66	41.44	
Other Variable Costs			
Dead Haul	23.76	23.76	
	100.00		100.00
Cost of Labor for Driving and the Dead Haul	42.42		

total cost. The actual cash outlay[1] amounted to 27.86 percent or 0.09 cents per bushel-mile, assuming no labor costs. The marginal cost was 41.44 percent of 0.34 cents, or 0.14 cents per bushel-mile. It is expected that this would be relatively constant for small increases in the hauling distances.

Stratification of Costs by Size, Age, and Annual Mileage of Trucks

Discussion to this point has been largely in terms of the total sample and the average cost for all of the trucks. To be of more practical value, it is necessary to have more specific costs than an overall average. To meet this requirement, there appeared to be a need for some stratification of the sample on the basis of size of truck, age of truck, and the annual mileages. The trucks were divided into sizes based on tonnage; into two age groups - 1960 and newer, and 1959 and older; and the mileage was broken down into three levels - less than, or equal to, 2000; 2001 to 5000; and greater than 5000. For each of the possible combinations, the average cost in cent per bushel-mile was calculated in the same manner as was done for the overall averages for the entire sample, and is presented in Tables IV-7 to IV-12.

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[1]The cash outlay includes the unavoidable costs required to operate a truck in which the owner has full equity. These costs include: lubrication, repairs, batteries and tires, utilities, maintenance and repair labor, and gasoline.

Three Ton Trucks. Table IV-7 shows the trucking costs for three ton trucks based on truck age and annual mileage and the portion of the total costs that are fixed costs. The cost declined for all three ton trucks as the annual mileage increased. For each mileage group the average cost was less for the oldest group than for the newest group of trucks. The cost varied from 0.64 cents per bushel-mile for the 1960 and newer trucks with an annual mileage of less than 2,001 miles. The lower cost of 0.13 cents per bushel-mile, was found to be for the 1959 and older trucks travelling more than 5,000 miles annually. The average cost for all three ton trucks was 0.26 cents per bushel-mile.

The percentage of the costs which were fixed declined with both age and increased mileages on the trucks. The 1960 and newer trucks travelling less than 2,001 miles annually had 69.5 percent of the cost fixed, while the 1959 and older trucks travelling more than 5,000 miles annually had 16.3 percent of the costs in the fixed cost category. The average fixed costs for all three ton trucks was 37.5 percent of the total costs.

Two Ton Trucks. Trucking costs for two ton trucks are shown in Table IV-8. The same pattern of cost relationships existed with two ton trucks as with three ton trucks. As the age or the annual mileage of the trucks increased the grain hauling costs decreased. The higher cost was 0.52 cents per

TABLE IV-7

AVERAGE TRUCKING COSTS FOR 3 TON TRUCKS
BASED ON ANNUAL MILEAGE AND AGE

Mileages	Averages	Age $\leq$1959	$\geq$1960	All
0-2000	No. of Trucks	15	5	20
	Cost	.41	.64	.46
	% Fixed Cost	38.70	69.50	49.20
2001-5000	No. of Trucks	6	4	10
	Cost	.22	.30	.25
	% Fixed Cost	30.90	55.90	42.90
5000 and up	No. of Trucks	2	8	10
	Cost	.13	.15	.15
	% Fixed Cost	16.30	30.90	28.30
All	No. of Trucks	24	19	43
	Cost	.27	.23	.26
	% Fixed Cost	29.70	39.00	37.50

bushel-mile for the 1960 and newer two ton trucks travelling less than 2,001 miles per year. The lower cost was 0.19 cents per bushel-mile for the 1959 and older trucks travelling in excess of 5,000 miles annually. The average cost for all two ton trucks was 0.34 cents per bushel-mile.

The same pattern was followed with the proportion of the total costs which were fixed, as with the transfer costs, with two exceptions. The 1960 and newer trucks travelling between 2,001 and 5,000 miles had 63.3 percent of the costs fixed; a percentage slightly higher than the same age group with less than 2,001 annual miles. The 1959 and older trucks travelling between 2,001 and 5,000 miles annually had the lower fixed cost ratio, 20.6 percent, slightly less than the older trucks travelling in excess of 5,000 miles annually. The average portion of total costs which were fixed, for all two ton trucks, was 41.9 percent.

One Ton Trucks. Table IV-9 indicates that the general trend in costs was the same as for the larger trucks. The newer than 1960 one ton trucks travelling less than 2,001 miles annually had a grain transfer cost of 1.56 cents per bushel-mile, while the same age group travelling more than 5,000 miles had a cost of 0.29 cents per bushel-mile. The average cost for all 51 one ton trucks was 0.49 cents per bushel-mile.

The proportion of the costs which were fixed varied from 57.4 percent for the 1960 and newer trucks travelling

TABLE IV-8

AVERAGE TRUCKING COSTS FOR 2 TON TRUCKS
BASED ON ANNUAL MILEAGE AND AGE

Mileages	Averages	Age ≤1959	Age ≥1960	All
0-2000	No. of Trucks	15	6	21
	Cost	.43	.52	.46
	% Fixed Cost	37.00	60.60	44.40
2001-5000	No. of Trucks	6	5	11
	Cost	.26	.39	.32
	% Fixed Cost	20.60	63.30	41.20
5001 and up	No. of Trucks	3	0	3
	Cost	.19		.19
	% Fixed Cost	23.00		23.00
All	No. of Trucks	24	11	35
	Cost	.30	.43	.34
	% Fixed Cost	29.30	63.10	41.90

less than 2,001 miles annually to 10.0 percent for the 1959 and older trucks travelling in excess of 5,000 miles annually. The average for all one ton trucks was 27.5 percent.

<u>Three-Quarter and One-Half Ton Trucks</u>. Tables IV-10 and IV-11 show the grain transfer costs and the portion of the total costs which were fixed, for the three-quarter and one-half ton trucks. Because the number of trucks in these size groupings was small some strata were vacant while those supplying data have very limited numbers of trucks involved. The average grain transfer costs for the three-quarter ton trucks was 0.65 cents per bushel-mile while the average cost for the one-half ton trucks was 0.71 cents per bushel-mile. In general, the costs decreased as both the age and the annual mileages of the trucks increased.

The average percentage of the costs which were fixed, for the three-quarter ton trucks was 24.9 percent. The corresponding percentage for the one-half ton trucks was 22.4 percent.

<u>All Trucks</u>. The grain hauling costs and the portion of the total costs which were fixed are given in Table IV-12. When all trucks were considered without regarding size, the average grain transfer costs decreased as both age and annual mileages of the trucks increased. The average grain transfer cost was 0.34 cents per bushel-mile. The 1960 and newer trucks travelling less than 2,001 miles annually, had a grain

TABLE IV-9

AVERAGE TRUCKING COSTS FOR 1 TON TRUCKS
BASED ON ANNUAL MILEAGES AND AGE

Mileages	Averages	Age $\leq$1959	Age $\geq$1960	All
0-2000	No. of Trucks	19	5	24
	Cost	.78	1.56	.95
	% Fixed Cost	34.50	57.40	42.30
2001-5000	No. of Trucks	15	3	18
	Cost	.47	.53	.42
	% Fixed Cost	18.40	43.40	26.00
5001 and up	No. of Trucks	5	4	9
	Cost	.37	.29	.33
	% Fixed Cost	10.00	45.50	19.30
All	No. of Trucks	39	12	51
	Cost	.47	.50	.49
	% Fixed Cost	9.40	45.90	27.50

TABLE IV-10

AVERAGE TRUCKING COSTS FOR 3/4 TON TRUCKS
BASED ON ANNUAL MILEAGE AND AGE

Mileages	Averages	Age ≤1959	≥1960	All
0-2000	No. of Trucks	1	0	1
	Cost	1.26		1.26
	% Fixed Cost	16.20		16.20
2001-5000	No. of Trucks	0	1	1
	Cost		.79	.79
	% Fixed Cost		16.40	16.40
5001 and up	No. of Trucks	1	2	3
	Cost	2.23	.54	1.10
	% Fixed Cost	4.40	30.40	12.80
All	No. of Trucks	2	3	5
	Cost	.85	.57	.65
	% Fixed Cost	14.30	28.60	24.90

TABLE IV-11

AVERAGE TRUCKING COSTS FOR 1/2 TON TRUCKS
BASED ON ANNUAL MILEAGE AND AGE

Mileages	Averages	Age ≤1959	Age ≥1960	All
0-2000	No. of Trucks	2	0	2
	Cost	1.11		1.11
	Fixed Cost	21.70		21.70
2001-5000	No. of Trucks	2	2	4
	Cost	1.26	1.09	1.17
	% Fixed Cost	14.30	44.10	28.10
5001 and up	No. of Trucks	0	2	2
	Cost		.51	.51
	% Fixed Cost		12.90	12.90
All	No. of Trucks	4	4	8
	Cost	1.17	.63	.71
	% Fixed Cost	16.40	23.60	22.40

transfer cost of 0.74 cents per bushel-mile. The 1960 and newer trucks travelling more than 5,000 miles annually had a grain transfer cost of 0.19 cents per bushel-mile, just 0.02 cents per bushel-mile less than the 1959 and older trucks with more than 5,000 annual miles.

The portion of the costs which was fixed decreased as both the age and the annual mileage of the trucks increased. The higher ratio was 63.5 percent for the newer trucks travelling less than 2,001 miles, while the 1959 and older trucks travelling in excess of 5,000 miles had 14.3 percent of the total costs as fixed costs. The average for all 142 trucks was 34.8 percent.

REGRESSION ANALYSIS

The theoretical model, postulated in Chapter II, was fitted to both the raw, and the log. form, of the trucking cost data. The resulting R^2's were 0.30 and 0.84 respectively. The corresponding F-values of 11.27 and 143.77 were both significant at the 5 percent level, with the log. form of the data being considerably the more significant. The model was a better fit when the data were transformed, as it had the greater R^2 and F-values. For the purpose of this study the following equation was utilized:

$$\log y = b_o + b_1 \log.X_1 + b_2 \log.X_2 + b_3 \log.X_3 + b_4 \log.X_4 + b_5 \log.X_5$$

TABLE IV-12

AVERAGE TRUCKING COSTS FOR ALL TRUCKS BASED ON ANNUAL MILEAGE AND AGE

Mileages	Averages	Age ≤1959	 ≥1960	All
0-2000	No. of Trucks	52	16	68
	Cost	.52	.74	.61
	% Fixed Cost	33.20	63.50	48.40
2001-5000	No. of Trucks	29	15	44
	Cost	.23	.38	.35
	% Fixed Cost	25.20	45.00	35.90
5001 and up	No. of Trucks	11	16	27
	Cost	.21	.19	.20
	% Fixed Cost	14.30	36.30	22.60
All	No. of Trucks	93	49	142
	Cost	.29	.42	.34
	% Fixed Cost	30.50	51.20	34.80

where:

y = estimated cost in cents per bushel-mile

b_o = constant

b_i = regression coefficients (i = 1, 2, ..., 5)

X_1 = miles in 000's travelled in the 1967-68 crop year

X_2 = one way hauling distance (miles)

X_3 = load size (bushels)

X_4 = percentage of non-paved roads

X_5 = age of truck

The model was fitted to the trucking cost data for all trucks together and for each truck size separately. The regression estimates are given in Table IV-13.

The regression coefficients for the "all truck" category were tested for statistical significance to determine whether the hypotheses postulated were empirically valid based on the findings of this study. When all trucks in the sample were considered, all regression coefficients had the hypothesized signs, and were, except for b_4, significant at the 5 percent level. Although b_4, road surface, was not significant, it was left in the equation for predictive purposes.

The coefficient of multiple determination, R^2, of 0.84, for all trucks in the sample, indicated that the equation had good explanatory powers showing that 84 percent of the variation in the dependent variable (Y) was explained by the variation in the independent variables (X_i) (i = 1, 2, ..5). When the truck sizes were considered separately the R^2's ranged from 0.88 for the three ton trucks to 0.77 for the two ton trucks.

For each size of truck the signs of all regression coefficients were as hypothesized, with one exception. All individual sizes of trucks showed a negative coefficient for road surface travelled on which was not paved. It was hypothesized that as the portion of non-paved roads increased the cost of hauling grain would increase, not decrease. However, the regression coefficient for road surface was not statistically significant. With the exception of trucks less than one ton, all other regression coefficients were significant at the 1 percent level. Thus, the empirical study supported the hypotheses with respect to annual mileage, hauling distance, load size, and age of truck. In the smaller size group of trucks, the annual mileage was significant at the 1 percent level and the hauling distance was significant at the 5 percent level; all other coefficients were insignificant.

The magnitude of the regression coefficients for annual mileage decreased as the size of the truck decreased. With the exception of the two ton trucks, the size of the coefficient for hauling distance increased as the size of truck decreased. This may be a result of a higher dead-haul cost per bushel load size as the truck size decreased. The coefficients for load size were considerably larger for the one ton trucks than for any other size. The age of truck was not statistically significant in the case of trucks less than one ton and was greater in magnitude for the one ton and three ton than for the two ton trucks.

In all sizes of trucks one ton or larger, the regression coefficient was largest for load size with annual mileage ranking second, hauling distance third, and truck age fourth; the one exception was where age and hauling distance ranked third and fourth respectively for three ton trucks. It may be observed that the average transfer costs decreased as distance and load size increased, although the rate of fall was less for the former.

From the empirical analysis, the following conclusions may be drawn with respect to the proposed hypotheses 2 to 6.

2. The cost per bushel-mile decreases with increased hauling distances.

3. The average cost per bushel-mile decreases as the truck miles per period increase.

4. The average cost per bushel-mile decreases as the size of the load increases.

5. The average cost per bushel-mile does not increase as the portion of non-paved roads increases.

6. The average cost per bushel-mile decreases as the age of the truck increases.

It was hypothesized that the average cost of transferring grain from the farm to the sales outlet in farmer owned

TABLE IV-13

REGRESSION ESTIMATES OF TRUCKING COST RELATIONSHIPS[a]

Size of Trucks	Constant	Regression Coefficients and Standard Error: Annual Miles in 000's X_1	Hauling Distance X_2	Load Size X_3	Road Surface Not Paved X_4	Age of Truck X_5	R^2
All Trucks	76.71	-0.4054** (0.0258)	-0.2982** (0.0332)	-0.7515** (0.0471)	0.0218 (0.0249)	-0.2340** (0.0307)	0.84
3	127.30	-0.5007** (0.0476)	-0.2756** (0.0667)	-0.7915** (0.1917)	-0.0014 (0.0348)	-0.2784** (0.0535)	0.88
2	48.87	-0.4588** (0.0708)	-0.2097** (0.0699)	-0.6899** (0.2645)	-0.0164 (0.0408)	-0.1776** (0.0544)	0.77
1	353.50	-0.3266** (0.0464)	-0.3230** (0.0525)	-1.0513** (0.2071)	-0.0020 (0.0339)	-0.2797** (0.0607)	0.79
Less Than One Ton	50.59	-0.3632** (0.0992)	-0.3875* (0.1203)	-0.6863 (0.4556)	-0.0404 (0.2695)	-0.0319 (0.2000)	0.85

[a]A one-asterisk superscript indicates the regression coefficient is statistically significant at the 5 percent level and a two-asterisk superscript indicates significance at the 1 percent level.

and operated trucks was 0.50 cents per bushel-mile. The calculated average based on the sample under study was 0.34. A "t" statistic was used as a test to determine whether there was a significant difference between the hypothesized 0.50 cents and the calculated 0.34 cents.

It may be concluded, as shown in Table IV-14, based on the sample under study, that the average cost, in cents per bushel-mile, for the farmers to haul their grain was, on the average, less than 0.50. The estimate made by this study was 0.34 cents per bushel-mile. A test was carried out on the average cost for the different sizes of trucks and, as shown in Table IV-14, the only trucks which, on the average, cost as much as 0.50 cents per bushel-mile were the truck sizes of one ton or less.

A comparison of the predicted transfer costs for different strata of trucks with the calculated average transfer costs of the same strata is shown in Table IV-15. The greater discrepancies may be found for the three-quarter and one-half ton size groups where the number in the sample was small. The predicted average cost, for all trucks, was 0.34 cents per bushel-mile, the same as the calculated average. The discrepancies between the predicted and the actual calculated average costs were both positive and negative with no apparent bias one way or the other. The same equation was used to predict the average transfer costs, of hauling grain, for each size of truck, stratified by age and annual mileage.

TABLE IV-14

TEST OF DIFFERENCES BETWEEN AVERAGE TRANSFER COSTS PER BUSHEL-MILE FOR DIFFERENT SIZES OF TRUCKS AND ONE-HALF CENT

Size of Truck	Number of Trucks	Mean of Sample	Variance of Sample	Std. Dev.	Calc. "t"	Theor. "t" 5%	Test
All	138	0.34	0.36	0.60	-3.10	1.65[a]	Reject
3	39	0.26	0.09	0.31	-4.83	2.02	Reject
2	35	0.34	0.09	0.30	-3.08	2.03	Reject
1	51	0.49	0.29	0.54	-0.20	2.01	Accept
< 1	13	0.66	0.54	0.24	0.45	2.18	Accept

[a]One tailed test

TABLE IV-15

COMPARISON OF ACTUAL AND PREDICTED TRANSFER COSTS FOR DIFFERENT SIZES OF TRUCKS IN THE STUDY

Size of Truck	No. in Sample	Actual Average Cost per Bu-Mile	Predicted Average Cost per Bu-Mile	Discrepancy
All	142	0.34	0.34	0.00
3	43	0.26	0.24	-0.02
2	35	0.35	0.35	0.00
1	51	0.49	0.50	+0.01
3/4	5	0.65	0.62	-0.03
1/2	8	0.71	0.74	+0.03

The predicted and the calculated costs may be found in Appendix C, Table C-1.

COMPARISON OF RESULTS WITH OTHER STUDIES

The major findings of this study have been outlined previously in this chapter. They have confirmed Young's conclusion that the size of the truck and the hauling distance have significant effect on the average per bushel-mile cost of hauling grain. However, the average cost was 0.34 cents as compared to the 0.50 cents per bushel-mile supported by Young. This study was unable to conclude that the dead-haul costs were the same regardless of the size of the truck, as was assumed by Young. The additional average cost to transport a bushel of grain one mile as a result of increased hauling distances was 0.14 cents, or 0.16 cents lower than the 0.30 cents predicted by Young.

The regression coefficients, for the two common variables, used in the regression analysis were both of the same sign, and were both significant at the 5 percent level. The magnitude of the regression coefficients for the truck capacity and the hauling distance were -0.70 and -0.16 respectively, in Young's analysis, as compared to -0.76 and -0.30 in this study. The R^2's were 0.46 and 0.84 respectively, indicating that the variables added in this study were valuable in terms of explaining the components which determined the final grain transfer costs.

The difference, of 0.13 cents per bushel-mile, in average transfer costs, between the two studies arises in two main areas; fuel costs, and repair and maintenance costs. The fuel, and repair and maintenance costs, were 0.05, and 0.09, cents per bushel-mile, respectively, higher in the Young study than in this study. Part of the discrepancy in the fuel cost may be accounted for by the change in policy, between the two survey periods, which now allows farm trucks to use tax free gasoline. No reason for the difference in repair and maintenance costs was evident, except that trucks may not have been kept in the same state of repair because of the economic conditions of the farm community during the 1967-68 crop year.

Parallel to this study, Moore carried out a cost analysis on small commercial and custom truckers to determine the cost of hauling grain from the farm to the sales outlet. The average cost, per bushel-mile for these truckers was calculated to be 0.29 cents per bushel-mile; compared to 0.34 cents per bushel-mile cost to farmers for farm owned and operated trucks. The average cost for the three ton trucks, in the Moore study, was 0.26 cents per bushel-mile, the same average cost as calculated for the farm trucks. Although the average costs were the same for the three ton group of trucks, the custom truckers carried 303 bushels with a one-way haul of 19.74 miles as compared to the farmers who hauled an average of 271 bushels 6.35 miles to the sales outlet.

In general, the average costs determined in this study were similar to those determined by Moore, and both were somewhat lower than the costs presented by Young.

CHAPTER V

ECONOMIC IMPLICATIONS AND CONCLUSIONS

The main points of discussion in this chapter will include a summary of the major findings of the study; implications of these findings to farmers, rail branchline abandonment, and the elevator system; and suggestions for further research.

SUMMARY AND GENERAL IMPLICATIONS

In this section an attempt will be made to draw some general implications from the findings in this analysis. One should realize the dangers of using an average aggregate cost such as the average cost of hauling grain. Such a cost is based on a large number of trucks of differing sizes, hauling distances, load sizes, ages, and annual mileages. The average cost is a valid statistical figure but is not necessarily a cost which is directly applicable to a specific trucker. There may be no trucker whose cost is the average, but these results do indicate the way in which certain factors (such as different sizes) may influence these costs.

The average cost of hauling grain to the sales outlet in farmer owned and operated farm trucks was estimated to be 0.34 cents per bushel-mile. This was significantly less than 0.50 cents per bushel-mile. The estimated average cost, marginal cost, of hauling an additional bushel-mile was 0.14 cents, or 1.40 cents to haul a bushel an additional 10 miles. This cost is based on the assumption of a constant average variable cost function over the relevant range and omitting the dead-haul cost which becomes a fixed cost for a specific load and does not change as the hauling distance changes. The impact of hauling increased distances above the average of 6.27 miles of the study appeared to be much reduced from both the average of 0.50 cents normally used, or the average of 0.34 cents determined by the current analysis.

The average cost for loading-waiting-unloading(dead-haul) varied from 54.45 cents for the one-half ton trucks to 108.68 cents for the three ton trucks, with the average being 88.25 cents. One cannot assume an equal dead-haul cost per load for all sizes of trucks; rather, the dead-haul cost per bushel decreased as the load size increased. Since the dead-haul cost is fixed once the decision to make the journey is made, the average dead-haul cost, per bushel-mile, varies inversely with the hauling distance. The larger the load and the longer the hauling distance, the lower was the dead-haul cost per bushel-mile.

The average speed travelled in hauling grain was 31 miles per hour. There was no significant difference in average speeds among the various sizes of trucks. As the hauling distance increased, it may be expected that more tarpaulins are used and that the average speed may increase. This study did not analyze the effect of speed on the cost of grain transportation.

The average housing cost for trucks, that were housed, was 0.01 cents per bushel-mile. This is a relatively small cost and may be considered insignificant in comparison with the total hauling costs.

As can be expected an increase in the cost of labor will increase the average cost per bushel-mile. Labor costs are significant in the trucking of grain, being 42 percent of the total cost. Should the cost of labor be considered to be near zero,[1] the average cost of grain transfer would be considerably less than the costs estimated by this study.

Load size, annual mileages, truck age, and hauling distance were found to have a significant effect on the average transfer cost of grain. As each of these variables increases, the average transfer cost per bushel-mile decreases. Of the four variables, load size, had the greater influence on costs.

This study showed that difference in road surfaces was not a significant factor in determining transfer costs of grain. However, one would hypothesize that for longer hauling distances significantly greater portion of total miles would

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[1]As long as the delivery pattern to the sales outlet is such that the farmer may deliver his grain at his leisure or when he has no other task to perform there may be no cost levied for labor. Should the delivery system be such that time limits are placed on the period within which the farmer may deliver his quota, delivery may be necessary at a time when the farmer is very busy. Under these conditions the cost for labor may be high which, in effect, would increase the grain hauling costs.

be travelled on hard surfaced roads. Although the sample under study found the road surface to be insignificant in determining transfer costs, intuitively one would expect the transfer cost to be less when the road surfaces were paved than when the roads were not paved. Because the paved portion of the roads travelled was relatively small, and because the hauling distances were relatively short the advantage of paved roads may not have been detected in this study.

The average fixed cost was 35 percent of the average total cost for all trucks. The variation in the fixed cost ratio for three ton trucks ranged from 69.5 percent for the newer than 1960 truck travelling less than 2,000 miles per year to 16.3 percent for the trucks older than 1959 travelling more than 5,000 miles. The newer higher-valued trucks with low mileages, because of the high average fixed costs, would necessarily have a higher per bushel-mile cost as compared to a low-valued truck used extensively. The average transfer costs for the two extremes in the three ton trucks were 0.64 cents per bushel mile for the 1960 and newer trucks travelling less than 2,000 miles annually, and 0.13 cents per bushel-mile for the 1959 and older trucks travelling more than 5,000 miles annually. In general, as the portion of fixed costs decreased within a size stratification, the average transfer costs also decreased.

If the farmer had full equity in his truck and operated it himself, the average cash outlay, was 0.09 cents per bushel-mile. With a cash outlay as low as 0.09 cents per bushel-mile, there might be a tendency for the farmer to reject the possible use of commercial trucking whose average cost, as determined by Moore, was 0.29 cents per bushel-mile.[2]

IMPLICATIONS FOR FARMERS

When large farm trucks were utilized extensively, with annual miles greater than 5,000, the average cost was 0.13 cents per bushel-mile. It may, in fact, be cheaper for the farmer to haul his grain a greater distance with a large truck than to haul his grain a short distance wit h a small truck. For example, a farmer having to haul 5,000 bushels a distance of 3.6 miles to the sales outlet in his 1963 one ton truck which travels 4,000 miles annually would have transfer costs of 0.53 cents per bushel-mile (Table IV-9), or a total cost of $90.40. To haul the same 5,000 bushels 6.83 miles in a 1953 three ton truck which travels 3,000 miles annually, the transfer cost would be 0.22 cents per bushel-mile (Table IV-7) for a total cost of $75.13.

Consideration must be given to other means of delivering grain to the sales outlet. The cost of hauling grain with a 1951 one ton truck travelling less than 2,000 miles was 0.78 cents per bushel-mile (Table IV-7). This would be 3.90 cents to haul a bushel 5 miles. Custom truckers charge an average

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[2] G.W. Moore, op. cit.

of 2.68 cents[3] to haul grain that same distance. This analysis did not attempt to determine the value of independence in truck ownership, although it may be an important factor in determining whether or not a truck should be owned.

IMPLICATIONS FOR BRANCH LINE ABANDONMENT

Over the past few years, considerable discussion has evolved concerning possible rail branch line abandonment. The findings of this study should aid in the determination of the expected increased grain hauling costs to farmers as a result of branch line abandonment, by supplying costs of moving grain by farm trucks. Such costs are required in analyzing the economic effect of branch line abandonment, on both the producer, and the rail company.

Since the average grain hauling costs per bushel are inversely related to the size of the truck (Tables IV-7 to IV-11) the farmers, by the use of large trucks, are able to haul their grain greater distances with little or no increase in the total grain hauling costs. It was suggested, earlier in this chapter, that the average cost of hauling grain an additional 10 miles was 1.40 cents per bushel. This being the case, the economic hardships which the farmers would suffer, as a result of hauling grain greater distances to the sales outlet, may not be as great as previously expected. The

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[3] G.W. Moore, _op. cit._

abandonment of uneconomical branch lines may, in fact, prevent an increase in freight rates.

IMPLICATIONS FOR ELEVATOR COMPANIES

The present grain handling system in the West is characterized by a profusion of small elevators located on closely-spaced railway lines. The system, with elevators spaced every 6 to 8 miles was based on the ability of the farmer to deliver his grain with the horse and wagon. With increasing costs of maintenance, repairs, and labor, many of the old elevators may not be replaced. The elevator companies will have to take a close look at their role in the grain industry.

Assuming the additional cost of hauling grain is 1.40 cents for 10 miles, the elevator companies must determine whether the additional service given and the reduced costs of operating fewer elevators is greater than the additional cost to the farmers. The savings in elevator and railway costs plus increased services offered may justify, economically, the increased hauling distances, by producers, if the savings are passed on to the producer.

SUGGESTIONS FOR FURTHER RESEARCH

1. To determine the most efficient means of grain movement, research is required to derive a model which would combine the cost structure of farm trucks, small commercial trucks, large commercial trucking operations, and the rail

system to determine the extent to which each may be utilized most efficiently over varying distances.

2. Research is required to determine the optimum size of elevators required to satisfy the demand for grain handling facilities in conjunction with the ability and requirements of the railway to handle the grain movement. When this is known, research will be required to put all factors together to determine the optimum elevator locations and the most efficient means of transporting the grain to these points.

3. Research is required to determine the optimum grain storage locations to meet sales obligations and to promote trade. Consideration must be given to storing grain in foreign countries, domestic inland terminals, the role of the country elevators in storage, and the possibility of increased on-farm storage.

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APPENDIX A

APPENDIX A

LITERATURE REVIEW

Within the past four decades the motor carriers have become strong competitors with the railways. With the dense network of rail lines, the railway companies finding that many branch lines are uneconomical, are becoming more reluctant to maintain these lines by internal cross-subsidization.[1] Along with rail rationalization, many elevators situated beside the remaining lines may disappear. In light of the grain industry rationalization, attempts have been, and are being, made to quantify the effects on the farmers, elevator companies, railways, and local communities. The predicted magnitude of the effects will vary depending on the cost figures used in calculating the additional cost to producers whose delivery points will be farther from the farm. It was found by a Saskatchewan study that:

> If current applications for abandonment in Saskatchewan becomes effective, many farmers will have to truck their wheat on the average of eighteen miles to elevators, compared to six miles now. It is estimated that the average age of farm trucks in Saskatchewan is twelve years and the average size is around one ton.

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[1] "Internal cross-subsidization" may be defined as the subsidization of an uneconomical line by those lines which realize a profit.

> Farmers will need newer and bigger trucks for longer hauls.[2]

Estimates used in determining the economic effect of planned changes appear to vary depending upon the final result desired.

> Reference has been made [by Young] to studies which have shown that the cost of hauling grain in a one-ton farm owned truck amounts to approximately one-quarter cent per bushel-mile. The Board of Transport Commission, however, has preferred to accept the figure of one-half cent per bushel-mile as the cost of additional haul, based on a survey of average custom hauling rates in Saskatchewan, as it has been shown that a number of farmers do not currently own trucks suitable for grain hauling.[3]

A study which has been used as a confirmation of the one-half cent per bushel-mile was carried out by Furniss[4] considering a 1954 one ton truck in the years 1955 and 1956. He concluded that the truck operating costs per mile were 12.3 and 13.7 cents respectively. Furniss did not interpret the cost in cents per bushel-mile, but Young has converted this to a cost of 0.20 cents per bushel-mile.[5] This figure, as stated by Young, does not include the driver cost.

Riordan[6] considered the influence of different road surfaces on the cost of trucking. Data were taken from the

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[2] J. Schriener, "Problem: Grain Elevators Without Tracks," The Financial Post, (December 5, 1964).

[3] K.B. Young, op. cit., p. 14.

[4] I.F. Furniss, op. cit.

[5] K.B. Young, op. cit., p. 17

[6] E.B. Riordan, op. cit., p. 29.

U.S. Highway Engineering Handbook and then adjusted in light of a separate study on Rural Mail Vans. Table A-1 indicates the estimated cost per mile of travel by farm trucks in hauling grain according to road surface.

An extensive study of trucking costs was undertaken by Young. He drew a random sample of 100 farms from five elevator points in southern Manitoba. Information was obtained from 89 of the 100 farms sampled. Sixty-six farmers owned trucks, while the remainder relied on custom truckers to haul their grain. Tables A-2 and A-3 give a summary of the average costs of operating a farm truck as determined by Young.

Young found that only two sizes of trucks had average assembly costs significantly different from the custom rate of 0.50 cents. They were the one-half to three-quarter ton trucks and the two to two and one-half ton trucks, with the former being higher and the latter being lower.[7] While the three ton trucks had an average cost of less than the custom rate, Young claimed the difference to be insignificant due to higher fixed cost of this group as compared to the two and one-half ton group.[8] Based on his analysis, there is

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[7] K.B. Young, op. cit., p. 87. TABLE XXIV.

[8] Ibid., p. 88.

TABLE A-1

ESTIMATED COST PER MILE OF TRAVEL BY FARM TRUCKS IN HAULING GRAIN ACCORDING TO ROAD SURFACE

Item	Paved	Road Surface Gravel	Earth
Average Running Speed	40 m.p.h.	30 m.p.h.	20 m.p.h.
Driving Time	1.5 min.	2.0 min.	3.0 min.
Truck Running Cost	3.942¢	4.738¢	5.382¢
Truck Stop and Start Costs	0.318¢	0.239¢	0.240¢
Labor Cost @ 1.5¢ a Min.	2.25¢	3.00¢	4.50¢
Total Cost Rounded	6.5¢	8.0¢	10.0¢
Ratios Between Total Costs	1 :	1.23:	1.54

Source: E.B. Riordan, Spatial Competition and Division Receipts Between Country Elevators. (Unpublished M.Sc. Thesis, University of Manitoba, February, 1965), p. 44.

TABLE A-2

YOUNG'S ESTIMATION OF THE AVERAGE, FIXED AND VARIABLE COSTS PER MILE OF FARM TRUCK OPERATION IN HAULING GRAIN

Size of Truck (tons)	Average Age of Truck (years)	Average Mileage 1964-65 Crop Year (miles)	Average Variable Cost per Mile (cents)	Average Fixed Cost per Mile (cents)	Average Total Cost per Mile (cents)
1/2 - 3/4	6	3,167	5.30	9.16	14.46
1	10	3,086	6.86	5.49	12.35
1 1/2	10	1,391	14.52	12.23	26.75
2 - 2 1/2	14	3,318	11.66	4.72	16.38
3	9	3,556	9.84	11.25	21.09
All	10.5	2,924	8.58	7.32	15.90

Source: 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, Winnipeg, Research Report No. 11, October, 1966), p. 79.

TABLE A-3

YOUNG'S ESTIMATION OF AVERAGE ASSEMBLY COST PER BUSHEL-MILE

Size of Truck	Average Bu.-Mile	Variable Cost per Bu.-Mile	Fixed Cost per Bu.-Mile	Dead-Haul Cost per Bu.-Mile	Labor Cost per Bu.-Mile	Total Cost per Bu.-Mile
1/2 - 3/4	11,271	.1660	.3236	.0926	.2127	.7951
1	23,954	.1994	.0938	.1043	.1459	.5167
1 1/2	22,761	.3110	.1471	.0314	.0851	.5747
2 - 2 1/2	31,650	.1232	.0685	.0325	.0742	.2984
3	27,777	.1291	.1331	.0362	.0674	.3658
All	24,020	.1876	.1153	.0553	.1129	.4713

Source: 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, Winnipeg, Research Report No. 11, October, 1966), p. 83.

evidence to believe that the average cost of hauling farm grain decreases as the size of the truck increases and as the hauling distance increases. The regression coefficients indicate that the load size is a more significant variable in reducing average costs than is the hauling distance.

The model used by Young to test the hypotheses was of the Cobb Douglas form. The same equation was used as a predictive model in estimating the average cost of hauling grain, given specific values for the independent variables. There was no indication that any variables other than size of truck, and hauling distance were used. With an "R^2" of 0.46, one would expect that other variables such as age of truck, road surface, and total annual mileage may be important. It should be noted that the predictions are estimated averages based on the sample under study and may not be valid if the relationship among the variables changes or costs change.

A more recent study, analyzing the cost components in grain assembly in a sample region in the Peace River District of Alberta, was undertaken by Groundwater and Winter.[7] One of the aspects of the study was the cost of delivering grain from the farm storage bin to the elevator. The model chosen for the analysis was taken from the Young study.

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[7]R.A. Groundwater and G.R. Winter, Cost Components in Grain Assembly, (Vancouver: Department of Agricultural Economics, The University of British Columbia, July, 1969).

Casavant and Nelson[8] carried out a study in North Dakota in which they analyzed the cost of hauling grain by large trucks over long distances. The trucks were mainly of the tractor and trailer type used in hauling the grain to the seaboard destinations. It was noted that there were economies of scale available to about 450,000 miles annually. Comparisons were made between the use of gasoline and diesel trucks as well a comparison between new and used equipment. It was found that there was excess capacity in the industry which may be contributed to the trades areas. Of specific concern to the truckers was the lack of a back-haul.[9] It is evident that the problem of a back-haul exists with the long haulers as well as with the short hauls from the farm to the sales outlet. If that problem could be overcome, the average trucking costs could be reduced significantly.

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

[9]A "back-haul" may be defined as a pay-load on the return trip.

APPENDIX B

APPENDIX B

SAMPLE CHARACTERISTICS

When faced with the task of determining the cost of hauling grain by farm trucks on the prairies, it was evident that limited resources and time prevented a complete analysis of each and every truck. With given constraints it was necessary to estimate the desired costs by analyzing a sample drawn from a population representative of the prairies. For the purpose of this study the geographical location chosen ran from just east of Winnipeg on the East; to Whitewood, Saskatchewan on the West; Carman on the South; and the Riding Mountains and Rorketon on the North.[1]

The area represents the majority of the various conditions which may be found in the grain-growing area of the prairies. The types of farms vary from large wheat farms to ranches with all combinations between the two extremes. The soil ranges from the Red River Gumbo, to sand dunes, to podzolic and most other soil types that one would find in any grain-growing area. The terrain varies from flat plains, to gently rolling plains, to hilly areas of the Parkland, and valleys of different depths. Within the area the railways have branch lines, mainlines, lines for which application for abandonment has been made, and areas where lines

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[1]The geographical area chosen and the delivery points selected are shown on the map; Figure B-1.

have already been lifted.

The random sampling[2] procedure was followed in selecting the 25 delivery points and the 8 producers from each delivery point. The producers selected from each of the delivery points were chosen from the 1967-68 list of permit holders as supplied by the Canadian Wheat Board. Thus, 200 permit book holders were chosen from whom data were requested.

Two hundred questionnaires[2] were mailed to the farmers and 155 were picked up personally approximately two weeks after being received by the farmers. Forty-five were not collected because some farmers could not be contacted and others, for personal reasons, would not co-operate in giving the desired information. Of those completing the questionnaire request, 23 did not have trucks or did not haul grain to the sales outlet. Nine or 5.8 percent used custom haulers. There were, however, 142 trucks used in hauling grain which were comprised of 46 three ton trucks, 35 two ton trucks,[4] 51 one ton trucks, 5 three-quarter ton trucks, and 8 one-half ton trucks. There was a bimodal distribution with respect to

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[2]For a discussion on sampling procedure see; W.A. Spurr and C.P. Bonnini, Statistical Analysis for Business Decisions, (Homewood: Richard D. Irvin, Inc., 1967), pp. 316-344.

[3]The questionnaire is included in Appendix D.

[4]Included in the two ton trucks were 2 two and one-half ton trucks and 6 one and one-half ton trucks.

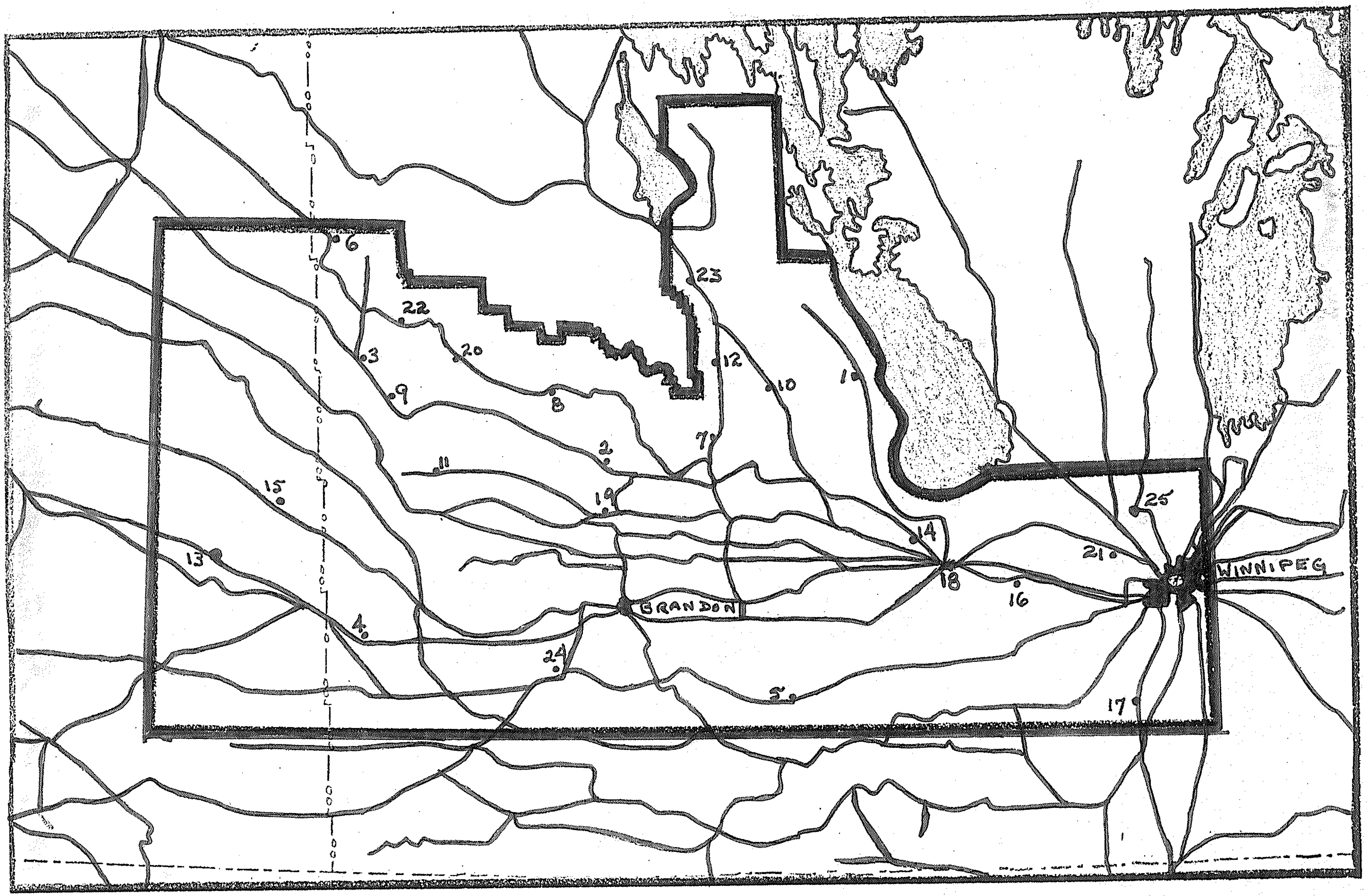

Figure B-1

Map of Survey Area

MAP KEY

1. Amaranth
2. Basswood
3. Binscarth
4. Cromer
5. Cypress River
6. Dropmore
7. Eden
8. Elphinstone
9. Foxwarren
10. Glenella
11. Isabella
12. Kelwood
13. Kelso, Sask.
14. MacDonald
15. Moosomin, Sask.
16. Newton
17. Osborne
18. Portage la Prairie
19. Rapid City
20. Rossburn
21. Rosser
22. Silverton
23. Ste. Rose
24. Souris
25. Stonewall

Winnipeg*
Brandon*

*Not in Survey Area

truck ages, with modes at 1964 and at 1952 with very few between 1955 and 1962.

The overall average load to capacity ratio[5] was 93.1 percent with 94.3 percent for the three ton trucks, 92.8 percent for the two ton trucks, and 90.8 percent for the one ton trucks. The average truck carried a load of 174.3 bushels an average of 6.27 miles for a one-way haul, and travelled an average of 3,415.5 miles annually.

The average price paid for gasoline was 25.9 cents per gallon. The average number of miles per gallon[6] and the average cost per mile are given in Table B-1. The average hourly wage rate reported was $1.72.

The number of miles the trucks were used in the delivery of grain to the sales outlet was small relative to the total annual miles travelled. The portion of the miles travelled in hauling grain varied from 3.45 percent for the three-quarter ton trucks, to 25.80 percent for the two ton trucks, with the average for the 142 trucks being 14.62 percent as shown in Table B-2.

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[5] "Load to capacity ratio" is defined as the ratio of the average size load carried to the capacity of the truck.

[6] In a personal conversation, a member of the Ford Motor Company estimated the average truck mileage per gallon to be about: three ton trucks - 7 m.p.g.; two ton trucks - 9 m.p.g.; one ton trucks - between 8 and 12 m.p.g. (depending on the load carried); three-quarter ton trucks - 12 m.p.g.; and one-half ton trucks - 16 m.p.g.

TABLE B-1

AVERAGE GASOLINE CONSUMPTION AND GASOLINE COSTS FOR DIFFERENT SIZES OF TRUCKS

Size of Truck (tons)	Average Truck Mileage (miles per gallon)	Average Fuel Price (cents)	Average Cost per Mile (cents)
1/2	17.8	25.9	1.45
3/4	14.7	25.9	1.76
1	12.2	25.9	2.07
2	9.9	25.9	2.61
3	8.4	25.9	3.08

TABLE B-2

AVERAGE SPEED AND PORTION OF ANNUAL MILEAGES DEVOTED TO HAULING GRAIN TO THE SALES OUTLET

Size of Truck	No. in Sample	Average 1967-68 Mileages	Percent of Miles Hauling Grain	Average Speed Hauling Grain
1/2	8	4866.75	14.50	28.75
3/4	5	5625.00	3.45	33.00
1	51	3378.04	16.22	30.48
2	35	2216.49	25.80	32.80
3	43	3986.83	9.67	30.73
All	142	3415.47	14.62	31.13

APPENDIX C

APPENDIX C

TABLE C-1

ACTUAL AND PREDICTED COST FOR ALL TRUCKS

		3 Ton		2 Ton		1 Ton		3/4 Ton		1/2 Ton	
Mileage	Cost	≤1959	≥1960	≤1959	≥1960	≤1959	≥1960	≤1959	≥1960	≤1959	≥1960
0 - 2000	# Trucks	15	5	15	6	19	5	1	0	2	0
	Actual	.41	.64	.43	.52	.78	1.56	1.26		1.11	
	Predicted	.40	.56	.44	.57	.82	1.10	1.30		1.16	
2001 - 5000	# Trucks	6	4	6	5	15	3	0	1	2	2
	Actual	.22	.30	.26	.39	.47	.53		.79	1.26	1.09
	Predicted	.25	.32	.28	.36	.46	.69		.82	1.14	1.13
5001 & up	# Trucks	2	8	3	0	5	4	1	2	0	2
	Actual	.13	.15	.19		.37	.29	2.23	.54		.51
	Predicted	.14	.21	.18		.30	.32	1.00	.55		.39
Overall Each Age & Size	# Trucks	24	19	24	11	39	12	2	3	4	4
	Actual	.27	.23	.31	.43	.47	.50	.85	.57	1.17	.63
	Predicted	.29	.24	.33	.45	.53	.52	1.00	.52	1.13	.59
Overal Each Size	# Trucks	43		35		51		5		8	
	Actual	.26		.34		.49		.65		.71	
	Predicted	.24		.35		.50		.62		.74	

APPENDIX D

APPENDIX D

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. licence. A custom trucker is one with a farm licence or standard licence 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								
5								
6								

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
(1) Parcel 1:	Miles of earth road	_____	_____
	miles of gravel road	_____	_____
	miles of paved road	_____	_____
	Total	_____	_____
(2) 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 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

Trucks	Truck A	Truck B	Truck C
Size			
Make			
Year			
Number of Cylinders			
Year & Month of Purchase			
Price Paid			
Present Value			

17. Truck Repairs

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

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

19. Utility Cost

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 ______

	Truck A	Truck B	Truck C
21. Licence costs			
Insurance Costs			
Other Costs specify			

22. Labor Costs	(Total hrs. trucking)	$/hr. value/hr.	Maintenance hours
Self employed and unpaid family			
Hired Seasonal labor			
Permanent hired labor			

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) % 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.

	Truck A	Truck B	Truck C
Box Capacity in wheat bushels			
Average load carried in wheat bushels			

SUPPLEMENTARY PART D

25.

	Shipping Point or Town Where 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?

____

____