GRAIN TRANSPORTATION COSTS AND CHARACTERISTICS FOR NORTH DAKOTA'S FARM TRUCKS

By

Gene C. Griffin
Robert J. Tosterud

UGPTI Publication No. 28
June 1975

GRAIN TRANSPORTATION COSTS AND CHARACTERISTICS FOR NORTH DAKOTA FARM TRUCKS

BY

GENE C. GRIFFIN
ROBERT J. TOSTERUD

Upper Great Plains Transportation Institute
North Dakota State University
P. O. Box 5074
Fargo, North Dakota 58105

in cooperation with

North Dakota State Wheat Commission
Bismarck, North Dakota

JUNE 1975

ACKNOWLEDGMENTS

The staff of the Upper Great Plains Transportation Institute acknowledges the North Dakota State Wheat Commission for its financial support of this research. Gratitude is also extended to information suppliers. The North Dakota Farmers Union and Farm Bureau is thanked for arranging meetings with area farmers to discuss this research and to obtain necessary data.

PREFACE

North Dakota Grain Handling and Transportation Evaluation and Rationalization

As a transportation research organization and North Dakota state agency, the Upper Great Plains Transportation Institute recognizes and accepts its local and regional responsibility, and is able, willing and obliged to provide the expertise and leadership in developing and carrying out a comprehensive research program in the area of transportation. One of its prime objectives is to significantly contribute to the long-run solution of grain transportation and handling problems currently plaguing our state and nation.

The title of the Institute's grain transportation research program is "North Dakota Grain Handling and Transportation Evaluation and Rationalization." This research program is split off into two directions. The first is a hard, objective evaluation of the total grain transportation and handling system as it currently exists. The system will be evaluated in terms of its current ability and future potential as a distributor of grain in light of long-run requirements that will challenge the system. The underlying philosophy adopted for this evaluation is that the most limiting factor facing North Dakota agriculture should be its ability to produce and the world's ability to consume rather than the inability to deliver. In essence, the burden of the grain transportation research program of the Institute is to design a transportation system that is capable of meeting the challenge of an efficient, productive North Dakota agriculture. The research program embodies the philosophy that the only legitimate limiting factor is the domestic and world demand for North Dakota grain not, for example, the supply of boxcars. One of the direct results of this evaluation will be an identification of bottlenecks in the system: where, when, how and why does the system collapse when we need it the most.

Once the existing system has been evaluated and bottlenecks and cause-effect relationships are brought to light, the second aspect of the research program is rationalizing the grain transportation and handling system. That is, developing, suggesting and, when and where possible, initiating a grain transportation and handling system which will maximize grain throughput at a minimum cost. In other words, with the knowledge gained during the evaluation process, we will be able to present reasonable and logical alternatives to present techniques used in handling and transporting North Dakota grain. Some alternatives might include: branch line abandonments; using existing elevators as satellites to an inland terminal system; perhaps an inland terminal system; a system composed of existing elevators capable of high throughputs; unit trains or multiple car "mini-unit trains;" and, perhaps even the feasibility of introducing alternative modes of grain transportation, like pipeline, air and barge. These are alternatives which if we don't look at, will simply go unappraised.

The scope and complexity of the problem necessitates, to say the least, a comprehensive research effort. The accompanying research program-project flow chart outlines the research procedure which will be followed to accomplish the objectives of the North Dakota Grain Handling and Transportation Evaluation and Rationalization program. This flow chart identified individual research projects that will have to be conducted. While specific project titles and objectives might change at some later date, the research project flow chart does portray a definite direction. This report is a step in that direction.

UGPTI RESEARCH PROGRAM/PROJECT FLOW CHART

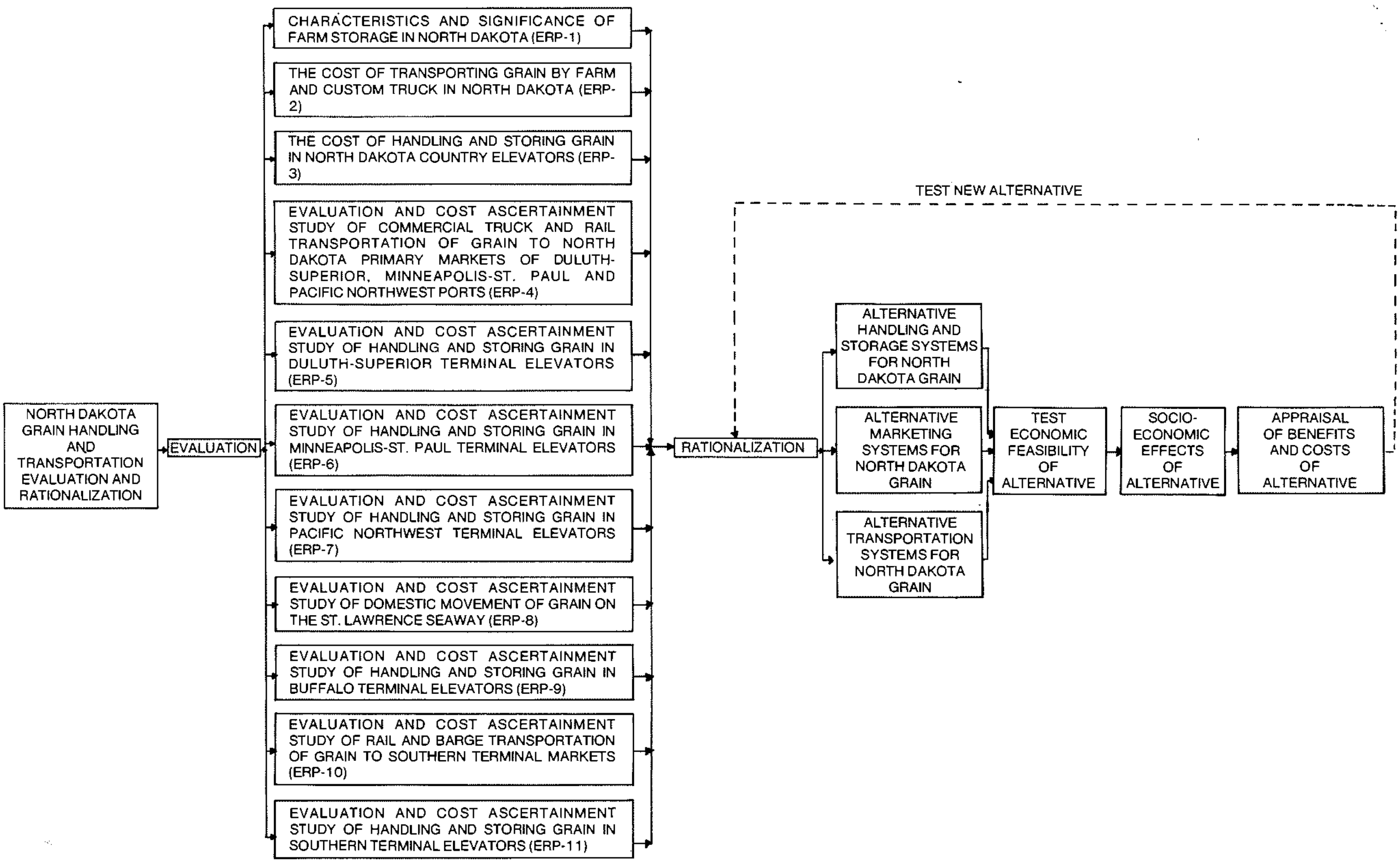

TABLE OF CONTENTS

	Page
ACKNOWLEDGMENTS	iii
PREFACE -- North Dakota Grain Handling and Transportation Evaluation and Rationalization	v
Chapter	
1. INTRODUCTION	1
Statement of the Problem	5
Objectives of Study	6
Area of Study	6
2. CONCEPTUAL FRAMEWORK	15
Theoretical Cost Concepts	17
Truck Size and Grain Transportation Costs	20
Truck Utilization and Grain Transportation Costs	21
Elevator Distance and Grain Transportation Costs	22
Truck Age and Grain Transportation Costs	22
Farm Size and Grain Transportation Costs	23
Summary of Relationships	24
3. METHODOLOGY	27
Source of Data	29
Cost Components	30
Assumptions	35
Calculation of Unit Costs of Grain Transportation	35
4. CHARACTERISTICS AND COSTS OF GRAIN TRANSPORTATION BY FARM TRUCK IN NORTH DAKOTA	37
Characteristics of Sample Farms	39
Production and Marketing Characteristics	39
Custom Hauling Characteristics	41
Farm Managers' Considerations in Selecting a Country Elevator	44
Characteristics of Grain Transportation	46
Farm Truck Characteristics	46
Characteristics of Grain Movements	47
Costs of Transporting Grain by Farm Truck	47
Total Costs of Grain Transportation	47
Unit Costs of Grain Transportation	50
5. IMPACT OF SELECTED FACTORS ON THE COST OF TRANSPORTING GRAIN BY FARM TRUCK	53
Size of Truck	55
Size of Truck Box	55
Truck Tonnage	59
Utilization of Truck	62
Total Annual Miles	62
Total Bushels Hauled	62
Bushel-Miles	65

TABLE OF CONTENTS (Cont.)

	Page
Age of Truck	68
One-Way Distance to Elevator	73
Farm Size	76
6. SUMMARY, CONCLUSIONS AND IMPLICATIONS	79
Summary and Conclusions	81
Characteristics of Grain Transportation	81
Total Costs of Grain Transportation	83
Impact of Selected Factors on Costs	83
Implications	85
Labor Costs	85
Size of Truck and Utilization	85
One-Way Distance to Local Elevator	86
Age of Truck and Farm Size	86
APPENDIX A	87

CHAPTER 1

INTRODUCTION

Chapter 1

INTRODUCTION*

The industry which transports America's grain is extremely complex often requiring the services of railroads, barges, motor carriers, inland lakers and ocean freighters. While each of these modes or services is critical to a successful grain sale, there is another part of this transportation system which is often ignored and taken for granted: the farm truck. It is the farmer-owned, and often operated, motor vehicle which initiates the massive movement of grain destined to feed America and the world.

Without the thousands of small, North Dakota farm trucks North Dakota's grain harvest would be, for all practical purposes, inaccessible and useless to both producers and consumers.

An estimated 60,000 North Dakota farm trucks are used each year to transport to local markets harvests and previously farm-stored grain ranging in volumes from 300 million to over 400 million bushels.[1] Assuming an average farm truck

---

*This study is modeled after: Tyrchniewicz, E.W., A.H. Butler, and O.P. Tangri, <u>The Cost of Transporting Grain by Farm Truck</u>, Center for Transportation Studies, University of Manitoba, Winnipeg, Manitoba, Research Report No. 8, July, 1971, 72 pp.

[1]While the North Dakota Motor Vehicle Department lists only 26,000 vehicles registered in the farm truck classification, this does not indicate the total number of farm trucks in the state. Many North Dakota farm trucks having gross vehicle weights less than 26,000 lbs. or greater than 58,000 lbs. are licensed in the "commercial" class due to the lack of a licensing incentive for these low and high weight categories.

load of 240 bushels, a 400 million bushel movement would require in excess of 1.6 million trips per year or 4,500 trips per day, 365 days a year.

The movement of grain produced in North Dakota to local markets via farm truck has far-reaching impacts and implications. The impact on the individual farmer-producer includes the cost of moving grain to local market, the capability to deliver in a manner consistent with marketing strategies and labor concerns. In addition, the movement of grain from farm to local market has impacts and implications for more than just the farmer-producer: A road and highway system capable of meeting the demands for such movement is necessary requiring large initial investment and continued maintenance; purchase of gasoline, tires, batteries, etc., and trucks themselves in local communities; and problems and bottlenecks occurring in farm to local market movements are transmitted throughout the grain marketing system. The transportation of grain from farm to local market is the first step and an integral part of the United States' and the world's grain transportation system. Therefore, any changes or problems that might occur during the initial movement of grain off the farm would have implications and consequences for the remainder of the grain handling and transportation system.

The number of farm trucks required and the magnitude of costs incurred during the movement of small grains from farm to local market is dependent on several factors including truck size, distance to local elevators, bushels transported, year of truck and others.

Statement of the Problem

The current methods and patterns of movement of grain from farm to local market could quite possibly change in the near future. In addition to the potential effects that future technology may have on the movement of grain from farm to local market, other factors such as the abandonment of railroad branch lines, the construction of large sub-terminal grain elevators, and energy considerations will determine, in part, future patterns and methods in the movement of farm grain. Currently, there is a desire by certain companies to abandon unprofitable branch lines. For example, the United States Department of Transportation has suggested that perhaps as much as 25 percent of all the trackage in the northeast portion of the United States should be abandoned. Branch line abandonment in North Dakota would have definite and direct impacts and implications for the individual farmer-producer, the communities which the branch line serves and the entire grain handling and transportation system of the United States.[2]

The immediate impact on the farmer-producer would be increased delivery distances, which would result in higher costs for moving grain from farm to local market. Future

---

[2]A more complete discussion of such implications and the grain transportation research program is given in the preface.

implications of abandonment for the farmer-producer include, but are not limited to: (1) changes in the percent of grain handled by custom haulers; (2) commodity price changes due to a change in freight rates and marketing strategies; (3) farmer-producer delivery to terminal market by semi-truck; (4) increased investment requirements for trucks to haul to local market; (5) increased costs of delivery to local market; and (6) social, political and economic changes in a rural area which ultimately affect the individual farmer-producer.

Objectives of Study

The general objective of this study is to determine the costs of moving grain from farm to local market by farm truck and what factors influence these costs. The specific objectives are:

1. To determine the average cost of moving grain from farm to local market by farm truck.
2. To evaluate the influence that the factors of box size, truck size, truck mileage, total bushels hauled, bushel-miles, farm size, elevator distance, and the age of the truck have on the various unit costs and total costs of moving grain from farm to local market by farm truck.

Area of Study

Northwestern North Dakota which includes the counties of Divide, Williams, Burke, Mountrail, Renville, Ward, Bottineau, McHenry, and Pierce and portions of the counties of McLean, Sheridan, Wells, Benson and Rolette is the study area (Figure 1). This area is designated as the "Williston-Minot Grain Handling and Transportation Rationalization Region" which is one of four such regions delineated within the state for transportation studies. The other three transportation study areas of the state are eastern, central and south-southwestern North Dakota (See Figure 1).

The study area is served by two railroads -- the Burlington Northern, Inc. and the Soo Line Railroad Co. (Figure 2). Both railroads have main lines and branches located throughout the region which service over 100 country elevators.

Highways within the region include U.S. 2, which runs east-west, U.S. 85 and U.S. 83 which run north-south, and U.S. 52 which runs diagonally across the region in a northwesterly-southwesterly direction (See Figure 2).

Similar to North Dakota generally, the region is predominantly agriculturally oriented with 95 percent of its total land area being in farms (Table 1). A majority (75 percent) of the land in farms is classified as cropland.

The predominant use of the cropland is in the production of small grains. Approximately 3,741,000 acres of wheat, barley, oats and flax were planted on cropland in 1973 in the Williston-Minot study area (Table 2). An additional 2,621,000 acres were summer fallowed during the same year which, more than likely, will be devoted to small grain production in 1974.

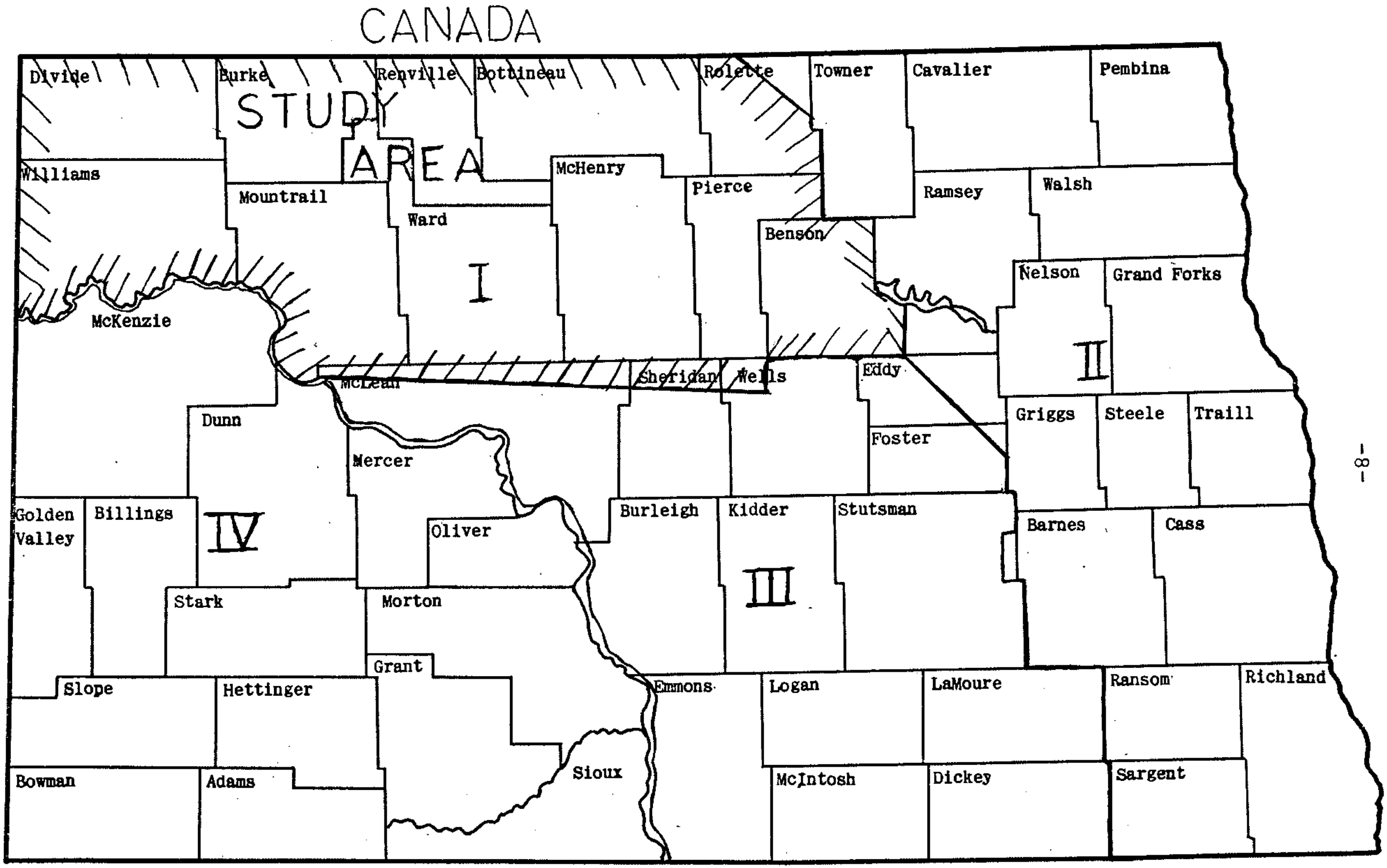

Figure 1. Study Area for Farm Truck Cost Study.

The Williston-Minot Grain Handling and Transportation Rationalization Region

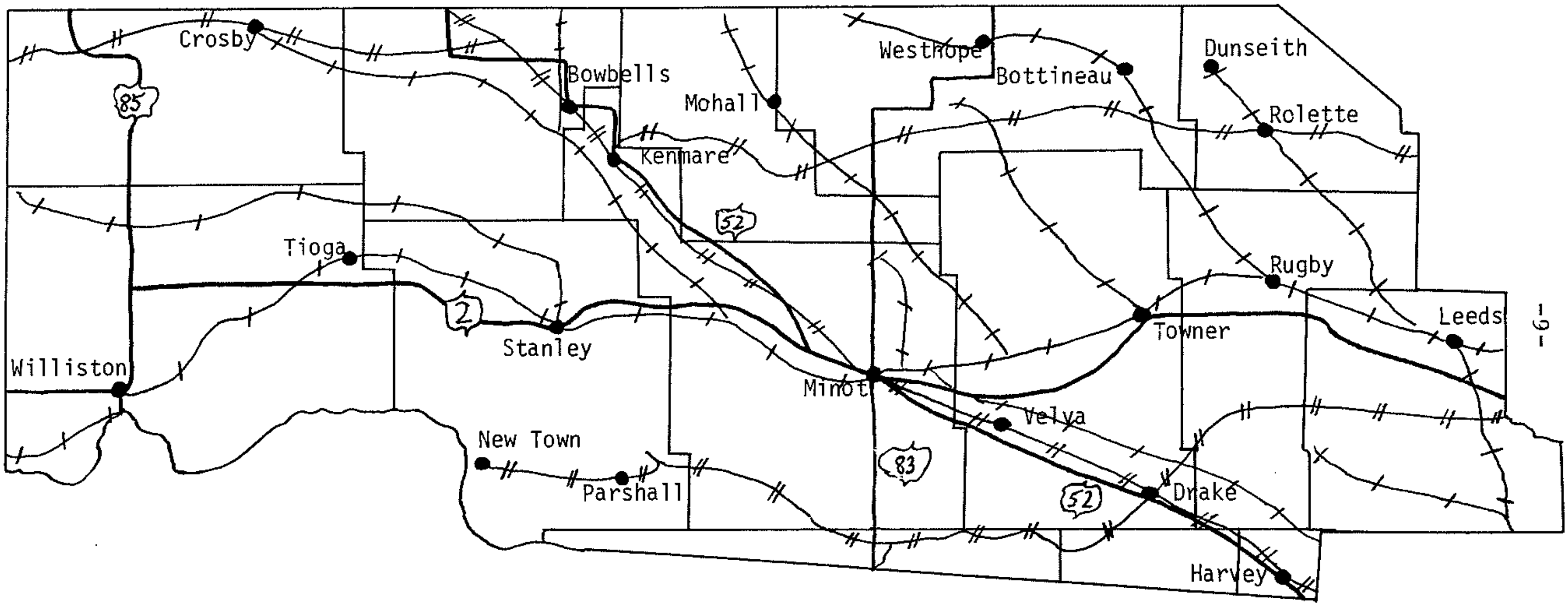

Figure 2. Location of Railroads, Major Highways and Selected Cities in the Williston-Minot Rationalization Region.

Burlington Northern, Inc.

Soo Line Railroad Co.

TABLE 1. LAND USE CHARACTERISTICS, FARM NUMBERS AND SIZES FOR NORTHWESTERN NORTH DAKOTA

Item	Unit of Measurement	Crop Reporting District One	Crop Reporting District Two	Study Area
Land Area	acres	5,908,480	4,422,144	10,330,624
Land in Farms	acres	5,658,554	4,210,301	9,868,855
Cropland	acres	4,082,153	3,310,814	7,392,967
Farm Numbers		5,908	4,846	10,754

SOURCE: Agricultural Census Data for North Dakota 1969, Department of Agricultural Economics, North Dakota State University, Fargo, North Dakota, October, 1972.

TABLE 2. CROPPING PATTERNS OF NORTHWESTERN NORTH DAKOTA FOR 1972-73

Item	Unit of Measurement	1972	1973
All Wheat			
Acres Planted	acres	2,159,200	2,577,500
Production	bushels	62,201,600	77,898,900
Hard Red Spring Wheat			
Acres Planted	acres	1,066,000	1,184,000
Production	bushels	30,041,500	34,159,000
Durum Wheat			
Acres Planted	acres	1,088,000	1,385,000
Production	bushels	32,046,600	43,539,000
Barley			
Acres Planted	acres	529,500	525,000
Production	bushels	20,008,000	19,970,500
Oats			
Acres Planted	acres	474,000	446,000
Production	bushels	23,333,000	19,439,000
Flax			
Acres Planted	acres	118,000	192,500
Production	bushels	1,541,100	2,232,500
Summer Fallow	acres	2,880,000	2,621,000
Alfalfa	acres	216,000	221,000
Tame Hay	acres	166,000	181,000

SOURCE: North Dakota Crop and Livestock Statistics, 1973 U.S. Department of Agriculture, Statistical Reporting Service, North Dakota State Statistical Office, Fargo, North Dakota.

Grain movements out of the region by rail and truck totaled 103,676,000 bushels in crop year 1973-74 and 108,786,000 bushels in 1972-73 (Table 3). Hard red spring and durum wheat constituted the bulk of such movements accounting for 72 percent and 76 percent of total movements in the years of 1973-74 and 1972-73, respectively.

TABLE 3. GRAIN MOVEMENTS FROM THE WILLISTON-MINOT GRAIN HANDLING AND TRANSPORTATION RATIONALIZATION REGION[a]

	1972-73							1973-74						
	Hard Red Spring Wheat	Durum Wheat	Barley	Oats	Flax	Rye	All Grains	Hard Red Spring Wheat	Durum Wheat	Barley	Oats	Flax	Rye	All Grains
	(000) bushels	(000) bushels	(000) bushels	(000) bushels	(000) bushels	(000) bushels	(000) bushels	(000) bushels	(000) bushels	(000) bushels	(000) bushels	(000) bushels	(000) bushels	(000) bushels
Duluth-Superior														
Rail	18,272	25,843	1,002	676	59	175		13,394	19,154	1,402	1,153	55	211	
Truck	2,637	3,743	1,545	1,571	659	257		2,459	2,552	856	1,542	115	276	
CCC	6	120	55	162	12	97		9	5	24	10	--	219	
Total[b]	20,915	29,706	2,602	2,410	731	530	56,894	15,682	21,710	2,282	2,705	169	706	43,254
Minn.-St. Paul														
Rail	8,122	7,922	6,796	2,460	156	75		5,098	7,292	8,477	2,674	277	120	
Truck	2,325	260	231	1,830	855	42		1,717	485	78	674	1,397	24	
CCC	15	169	49	476	58	104		95	13	--	126	--	11	
Total[b]	10,462	8,351	7,076	4,766	1,069	221	31,945	6,909	7,790	8,555	3,474	1,674	157	28,559
West														
Rail	5,717	428	1,856	394	--	--		11,154	1,447	2,200	1,244	--	--	
Truck	129	91	1,791	1,230	136	105		736	238	1,125	2,113	39	87	
CCC	254	--	--	--	--	2		--	--	--	539	--	--	
Total[b]	6,100	519	3,647	1,624	136	106	12,132	11,890	1,686	3,326	3,897	39	87	20,925
All Destinations														
Rail	34,723	36,756	9,915	4,164	217	17		33,483	30,651	12,380	5,655	346	354	
Truck	5,434	4,719	3,958	5,661	1,706	20		5,562	4,374	2,814	5,032	1,577	395	
CCC	361	289	103	663	72	11		104	18	24	676	--	231	
Total[b]	40,517	41,763	13,976	10,487	1,994	49	108,786	39,148	35,043	15,218	11,364	1,923	980	103,676

[a]Crop reporting districts one and two, consisting of the counties of Divide, Williams, Burke, Mountrail, Renville, Ward, Bottineau, McHenry, Rolette, Pierce, and Benson were used to estimate movements from the region.

[b]May not add due to rounding.

SOURCE: Grain Movement Reports, North Dakota Public Service Commission, Bismarck, North Dakota.

CHAPTER 2

CONCEPTUAL FRAMEWORK

Chapter 2

CONCEPTUAL FRAMEWORK

Theoretical Cost Concepts

Resources used in the production of a good or service in the short run can be classified as either variable or fixed. The short run is defined as a time period in which some factors are fixed. Fixed resources are defined as those resources whose quantity cannot be changed during a given production period; e.g., the land in a farm during any one growing season is an example of a fixed resource. Variable resources are defined as those resources used in the production process whose level of use can be varied, such as fertilizer. In the long-run time period all resources are variable to the individual firm or producer.

The classification of resources into two types results in two types of costs, variable costs and fixed costs, which, in turn, are directly related to variable and fixed resources. Fixed costs are constant during the production period and constitute a single obligation regardless of the level of output. Variable costs, on the other hand, vary with the level of output. Typically, variable costs will increase as output increases.

Per unit costs, which are derived from fixed, variable, and total costs, are utilized in describing and analyzing costs in a more usable and understandable form. Per unit costs consist of average fixed cost, average variable cost, average total cost and marginal cost. Average fixed cost is fixed costs per unit of production at various levels of output (Figure 3). Because of the nature of fixed costs, average fixed cost declines as output increases. As production increases, the fixed cost is spread over more units of production; e.g., the fixed cost per bushel of a farm truck such as depreciation and interest on investment would decline as the number of bushels hauled increased.

Average variable cost measures the variable cost per unit of output at various levels of output and is generally a 'U' shaped curve (Figure 3). For purposes of this study, only the downward sloping portion of the curve (Section AB in Figure 3) is relevant because of the limited utilization of the farm truck; that is, a farm truck is rarely, if ever utilized to the extent where average costs begin going up.

Total average cost is simply the average variable cost plus the average fixed cost.

Marginal cost is defined as the change in total cost resulting from a change in production of one unit. The marginal cost curve is also 'U' shaped.

Per unit costs of hauling grain are definitely of the theoretical nature of the cost curves just described; however, it is difficult to measure them as such because of the lack of uniformity of farm trucks and managerial ability. Nevertheless,

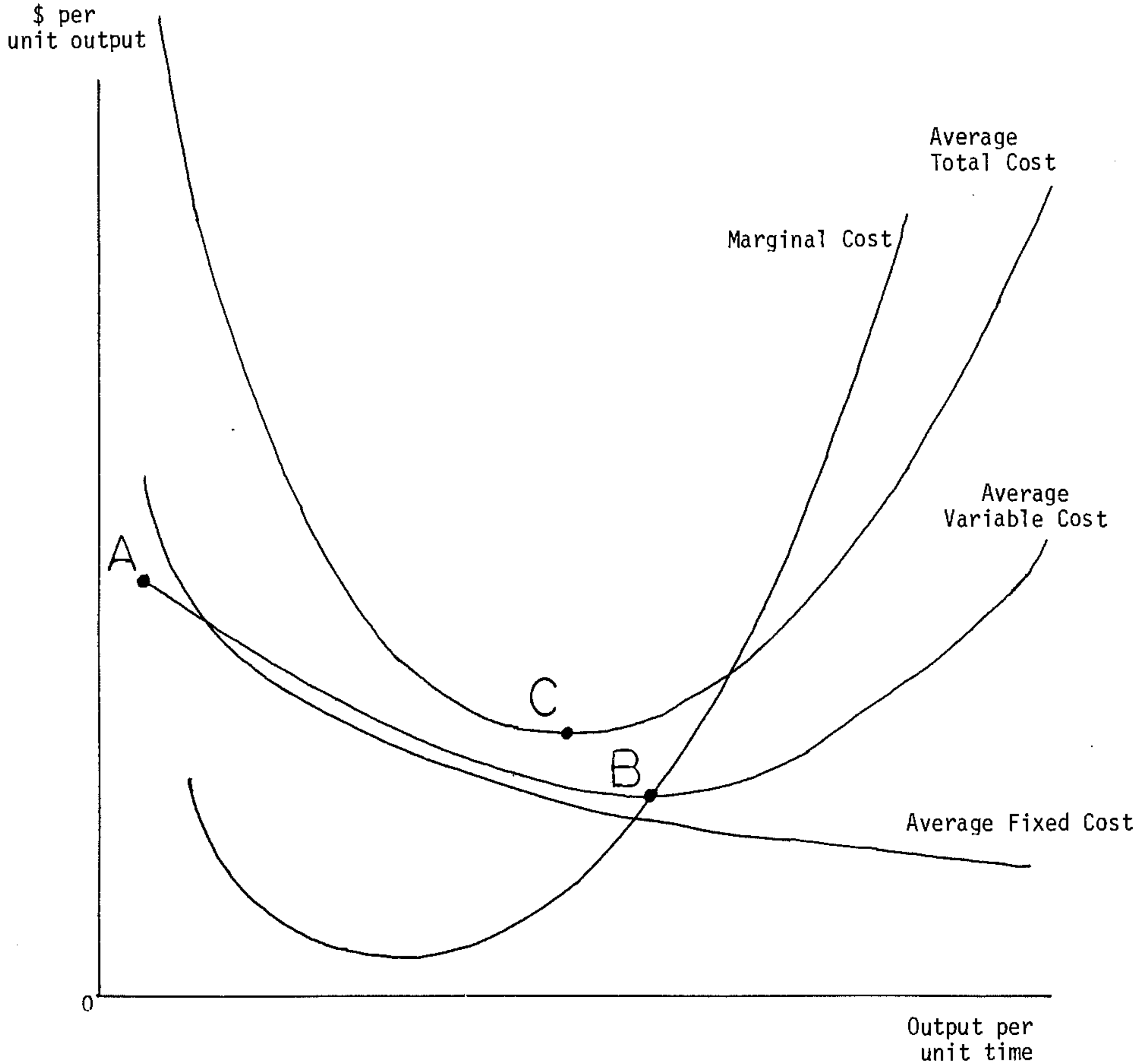

Figure 3. Unit Cost Curves.

the theoretical cost curves do provide a framework from which farm truck cost data can be analyzed.

Truck Size and Grain Transportation Costs

Theoretically and practically, it would be expected that the size of a truck would influence the cost of transporting grain from farm to country elevator. As the size of the truck increases, per unit costs of transporting grain should decrease, other things being equal such as the bushels hauled and distance to the delivery point.[3] Total and per unit costs will be higher for the smaller truck. Such fixed cost items as depreciation, interest on investment, license and insurance will be greater for a larger truck than a smaller truck in the aggregate because of the increased cost of the equipment, weight, etc. Assuming that two trucks transport the same number of bushels, per unit fixed costs will also be larger for the bigger truck. Variable costs, on the other hand, should be less for the larger truck than for the smaller truck. This would be expected because the larger truck would have to make fewer trips than the smaller truck to handle the same quantity of grain. If a sufficient quantity of grain were handled by the larger trucks, one would expect that the decrease in variable costs would more than offset the increase in fixed costs and thus total per unit costs of handling grain would be less for a larger truck.[4]

---

[3]Assuming that a sufficient amount of grain is handled such that the output of both trucks is within the "reasonable zone of production."

[4]If only small amounts of grain are handled, this would not necessarily be true.

Truck Utilization and Grain Transportation Costs

As the utilization of a given truck increases, the cost per unit of output is expected to first decrease and then, at some degree of use, start to increase. The utilization, or output of a truck may be measured in several ways including truck mileage, bushels hauled or bushel-miles. The manner in which utilization is measured should not affect the general relationship between utilization and per unit costs. The relationship decribed above, results in a 'U' shaped total cost curve on a per unit basis (See Figure 3).

The reason for the negative-positive relationship between utilization and total average costs is because of the nature of the variable costs. Fixed costs decrease per unit of production as production (truck utilization) increases since by definition fixed costs are absolute with respect to output and do not change. However, average variable costs decrease as a truck's utilization is increased until at some point they start increasing per unit of production (See point C in Figure 3).[5] Increasing variable costs will at some point offset decreasing fixed costs per unit of production and as a result total average costs per unit of production will begin to increase with output. However, as stated earlier, the portion of the total average cost curve which is considered relevant for farm-trucked grain is that part which shows only decreasing average costs.

---

[5]The 'U' shaped nature of the average variable cost curve is derived from the principles of production.

Elevator Distance and Grain Transportation Costs

The relationship between the costs of transporting grain and the distance to the elevator is similar to the relationship involving truck utilization. Given that the distance to the elevator is the difference in two grain moving operations, it would be expected that per mile costs and per bushel-mile cost for moving grain would be greater for the operation nearest the elevator because of the relative utilization of the two trucks. The reasoning underlying such an interpretation is the spreading of fixed costs over more miles or bushel-miles for the more distant grain moving operation.

Although increased elevator distance will decrease total costs on a per unit basis because of fixed costs, certain variable costs also decline on a per unit basis as the elevator distance increases. Dead-haul costs are an example of such a variable cost item. Dead-haul costs are those labor costs associated with loading, unloading and waiting at the elevator. Dead-haul costs, although variable in nature, are fixed for a given trip. Thus, as the distance the elevator increases and, correspondingly, the bushel-miles, dead-haul costs per unit of output decline. The distance to the elevator and per unit costs, therefore, have a negative relationship.

Truck Age and Grain Transportation Costs

The relationship between the age of the truck and unit transportation costs is not clearly defined in theory. As the age of a truck increases, the value of the truck decreases. This would indicate a negative relationship between depreciation and interest on investment costs and the age of the truck.[6] However, variable costs may increase with age due to the requirement for more frequent repairs. The hypothesis of a positive relationship (as age increases, per unit costs increase) between age and repairs is difficult to analyze because of the capability of rebuilding a truck and what effect time versus utilization has on the various components of a truck which require repairs.

Assuming that repairs do increase with the age of the truck, the resulting question is what affects costs more significantly: increased variable costs due to repairs or decreased fixed costs resulting from the decreased value of the truck as its age increases? Because of the low level of utilization suspected in farm trucks, the effect of decreased fixed costs may offset the increased variable costs resulting in a negative relationship between per unit costs of grain transportation and the age of the truck.

Farm Size and Grain Transportation Costs

The relationship between farm size and unit grain transportation costs is related to truck utilization and truck size. It would be expected that as farm size increases, production and, correspondingly, the bushels delivered, also increases. Therefore, it would be expected that truck

---

[6]An argument against such an approach would be the use of average value rather than current value.

utilization and truck size would both increase as farm size increases. Since the relationship between unit grain transportation costs and truck utilization and truck size is a negative one, it would therefore be expected that as farm size increases, unit grain transportation costs decrease, other things being equal. It should be noted, however, that this general relationship may not always hold true. A specific case in point would be when a farm reaches the size that requires two trucks for purposes of transporting grain to local market in a timely manner consistent with marketing strategies but is not a large enough farm to utilize the trucks to the point that fixed costs per unit of transportation are reduced significantly versus a smaller farm.

Summary of Relationships

The general relationships which are expected to be found in this study are as follows:

1. The average cost per bushel-mile of farm truck grain transportation decreases as the size of the truck, measured in tons and box size, increases.
2. The average cost per bushel-mile of farm truck grain transportation decreases as the utilization of the truck increases. Farm truck utilization is measured in this study by truck mileage, bushels hauled and bushel-miles.
3. The average cost per bushel-mile of farm truck grain transportation decreases as the distance to the elevator increases.

4. The average cost per bushel-mile for a farm truck will decrease as the age of the truck increases.

5. The average cost per bushel-mile for a farm truck will decrease as the size of the farm increases.

Although it is expected that these general relationships will be shown to exist by analysis of the data, it must be pointed out that inconsistencies within a relationship may exist because of the lack of uniformity of managerial capability of farm managers, a lack of uniformity among trucks, and for other reasons.

CHAPTER 3

METHODOLOGY

Chapter 3

METHODOLOGY

Source of Data

The optimum sample in terms of reliability is, of course, the entire population. However, this is impossible in almost all studies because of the size of the population and time and financial constraints. Thus, it is necessary to select a random sample of the population which hopefully will be representative of that population. A sample of farms and correspondingly, trucks utilized in moving grain during the 1973 calendar year was taken from the study area to provide data for analysis. Questionnaires were mailed to farmers and also distributed to farmers through farm organizations. Farm operators who chose to complete the questionnaire returned them by mail. Approximately 10 percent of the questionnaires which were distributed were returned. Mailing addresses for the questionnaires were acquired by choosing every tenth truck registered with the North Dakota Motor Vehicle Department in the study area.

The sample consisted of 193 farm trucks reported from 130 farms. The number of farms was less than the number of trucks because some farms had more than one truck; 63 farms which had 2 trucks answered the questionnaire. The questionnaire was constructed in such a manner as to allow determination of costs for individual trucks if a farm operator reported on more than one truck (Appendix A).

Cost Components

Costs were classified as being either fixed or variable. Fixed costs included depreciation, interest on investment, license, insurance and housing. Variable costs consisted of lubrication, fuel, tires and batteries, tune-ups, repairs, engine overhauls, repair labor, dead-haul and driving labor and miscellaneous cost items.

The fixed costs were defined and calculated as follows:

1. Depreciation -- Depreciation was defined as the reduction in value of the truck over time due to usage and/or time. Depreciation due to usage was included as a fixed cost although it is more correctly identified as a variable cost. However, the difficulty in proportioning total reduction in value between usage depreciation and time depreciation led to the inclusion of total depreciation in the fixed cost category.

Trucks are classified as capital assets and as such require the use of depreciation to determine the real cost of ownership and operation. A truck which is purchased in one time period is expected to be utilized and deliver useful life for several time periods. Thus, the monetary outlay is made at one point in time and the usefulness of the asset is consumed over many time periods. It is the consumption of this asset in different time periods that is identified as depreciation cost.

Several methods of depreciation are available to the businessman, including the farm manager, such as straight line, declining balance, and sum of years digit methods. A simple approach for determining depreciation was used for this study. Depreciation was calculated on the basis of the difference between purchase price and present value, and the years of ownership. Thus, the average decline in value was determined by dividing total decrease in value by the number of years of ownership.

2. Interest on Investment -- Interest on investment is either an out-of-the-pocket cost or an opportunity cost incurred by the owner of a capital asset. An out-of-the-pocket cost is experienced by the owner of a capital asset when the asset is either wholly or partially debt financed. The cost in this case is the interest paid on the borrowed funds necessary for the purchase of the asset. If an asset is financed internally from monies owned by the firm, then an opportunity cost is incurred by the owner of the capital asset. The opportunity cost arises from the fact that the money used to purchase an asset could be used elsewhere within or outside the firm for some productive purpose. For instance, had a farm manager not purchased a truck, the money could be used to purchase other farm inputs which would show a return or it could be deposited in a bank in the form of a savings account or certificate of deposit which would earn a return.

Interest on investment was calculated at 7 percent of the present value of the truck. Assuming the sample was of a random nature, the present value of all observations would average out to be representative of the average value of trucks on farms. The interest rate of 7 percent might be considered conservative relative to today's current interest rates and rates of return offered on selected bonds and deposits. However, it is representative of interest rates over time.

3. License Fees -- License fees are an annually recurring cost having no relationship to utilization of the truck and as such were classified as a fixed cost. North Dakota bases the license fee on the model year, registered vehicle weight and the type of service for trucks.

4. Insurance -- Insurance costs for farm trucks are similar in nature to license fees in that they are recurring in nature and are not related to the utilization of the truck and, therefore, were classified as fixed costs.

5. Housing -- Housing costs associated with the farm truck were categorized as being fixed. Costs were calculated on the basis of the value of the building used for housing the truck, the percentage of total space the truck utilized and a 7 percent rate of interest. The cost incurred was the same as that considered on interest on investment.

The variable costs were defined and calculated as follows:

1. Lubrication -- Lubrication costs are usually associated with the operation of a truck and as such were classifed as

variable costs. The cost of lubrication included grease, oil, filters and antifreeze.

2. Fuel -- The gasoline used in trucking grain is directly related to the use of the truck and, therefore, was identified as a variable cost. Fuel costs were based on total consumption and an estimated price per gallon for gasoline. Gasoline requirements were based on the total miles a truck was operated and the average gasoline consumption in miles per gallon. The price of gasoline was estimated at 35 cents per gallon.

3. Tires and Batteries -- Time as well as usage contributes to the deterioration of tires and batteries. Farm truck tires typically sustain extensive weathering damage because of low annual mileage. Tires and batteries are not usually replaced on an annual basis because of low annual mileage. These costs were treated as variable costs assuming that usage was a more important factor in deterioration and that a random enough sample was taken to indicate the average annual cost of replacement.

4. Tune-up -- Tune-up costs are related to usage, driving habits, and management and maintenance practices. These costs, which included spark plugs, points, condenser, pcv valves, etc., were treated as variable costs. It was recognized that tune-ups may not occur on an annual basis, but as in the case of tires and batteries, it was assumed that the sample was random and that the average of all trucks would indicate the annual cost for all trucks over time.

5. Repairs -- Repair costs were inclusive with the exception of tune-ups and major engine overhauls or engine replacement. Repairs included the cost for such items as fan belts, seals, bearings, clutches, water pumps, starters, etc. Some repairs, such as engine overhauls, are required on only a periodic basis and, it can be argued, that such repair costs should be spread out over a time period reflecting the elapsed time between similar repairs. However, because of the time variability in farm truck repairs, it was necessary to average these costs for all sampled farm trucks and to consider them variable.

6. Engine Overhauls -- Engine overhaul costs were treated in the same manner as repair costs.

7. Repairs Labor -- Repair labor was defined as the labor requirement for tune-ups and repairs which were performed by the farm operator. The time spent performing such tasks was taken directly from the questionnaire. The rate used for calculating labor repair costs was $2.50 per hour.

8. Driving and Dead-Haul Labor -- Driving labor was defined as the time required to drive to and from the unloading point and time spent in loading. Dead-haul labor included unloading and waiting at the delivery point. Driving and dead-haul time per trip was taken directly from the questionnaire. Total time was calculated by multiplying the number of trips times the per trip time requirement. The labor rate used to estimate costs was the same as that

used for repair costs, $2.50 per hour.

9. Other Costs -- A variable cost category for miscellaneous costs was used to identify items which had not been previously categorized.

Assumptions

All costs were computed on an annual basis for all truck operations. Therefore, it was necessary to weight the costs in such a way as to lead to those costs which could be directly attributable to the transporting of grain from the farm to local elevator. The costs were weighted employing a ratio which reflected truck miles used in transporting grain versus annual truck miles. For example, if 75 percent of the trucks total annual miles were spent in transporting grain, then 75 percent of the costs were attributed to the hauling of grain. All costs were weighted with the exception of driving and dead-haul labor costs and fuel costs which were computed individually for grain transportation.

Calculation of Unit Costs of Grain Transportation

Total costs for each truck were computed from the individual components of fixed and variable costs. An average fized, variable and total cost was then computed from the totals for each truck. Where appropriate, all cost components were weighted. Unit costs were determined on a per bushel, a per grain-mile and a per bushel-mile basis.[7] Unit

---

[7]Grain miles are defined as the total miles that a truck accounted for in transporting grain from farm to local market. Bushel-miles are defined as the total bushels transported times the one-way distance to the delivery point.

costs were based on the average fixed, variable and total costs and the average bushels transported, miles traveled in transporting grain and one-way distance to the elevator.

Formulas for the preceding costs mentioned are as follows:

1. Average total annual grain transportation costs = (total weighted fixed costs + total weighted variable costs[8]) ÷ number of trucks in sample or stratification.
2. Average cost per grain mile = average total annual grain transportation costs ÷ annual truck miles in grain transportation.
3. Average cost per bushel = average total annual grain transportation costs ÷ annual total bushels of grain transported.
4. Average cost per bushel-mile = average total annual grain transportation costs ÷ (annaul total bushels of grain transported X one-way distance to elevator.

---

[8]Cost components were weighted when appropriate.

CHAPTER 4

CHARACTERISTICS AND COSTS OF GRAIN TRANSPORTATION BY FARM TRUCK IN NORTH DAKOTA

Chapter 4

CHARACTERISTICS AND COSTS OF GRAIN TRANSPORTATION BY FARM TRUCK IN NORTH DAKOTA

Characteristics of Sample Farms

Farm truck data for 1973 were provided by 130 farms for 193 farm trucks. Sixty-eight farms reported owning one truck, sixty-one farms reported owning two trucks and one farm reported owning three trucks, for an average of one and one-half trucks per farm. The average size of farms sampled was 1,376 acres.

Production and Marketing Characteristics

Wheat, consisting of hard red spring and durum, was the dominant crop produced by the farms in the sample. These farms produced in 1973, 811,954 bushels of hard red spring wheat and 868,034 bushles of durum (Table 4). This quantity of grain constituted 71 percent of all grain produced by the sample farms. Eighty-seven of the 130 farms produced hard red spring wheat and 101, durum wheat (Table 4). Barley and oats were the second and third most significant crops, respectively, in terms of bushels produced: 341,299 bushels of barley were produced by 66 producers and 302,670 bushels of oats were produced by 81 producers in 1973. The remaining production, which consisted of flax, rye and other crops, comprised only 3 percent of total production and accounted for 73,575 bushels.

TABLE 4. CROP PRODUCTION AND MARKETINGS OF FARMS ANSWERING QUESTIONNAIRE, 1973

Crop	Production in 1973	Marketings[a] in 1973	Number of Producers	Number of Sellers
	(bushels)	(bushels)		
Hard Red Spring Wheat	811,954	823,899	87	91
Durum Wheat	868,034	859,859	101	102
Barley	341,299	276,070	66	61
Oats	302,670	239,342	81	47
Flax	48,325	41,749	8	7
Rye	22,750	23,950	41	39
Other	2,500	--	1	--

[a]Includes only those marketing at country elevators.

Nearly as much grain was marketed as was produced in 1973 by the farm managers included in the survey. Marketings totaled 2,264,869 bushels in 1973 while production totaled 2,397,532 bushels during the same time period. Marketings followed the same trends as in production with hard red spring and durum wheat being the most dominant. The number of sellers also followed the trend of number of producers with the exception of oats. It was assumed that the number of sellers of oats was much less than the number of producers because of farm operators growing oats as an intermediate crop for purposes of livestock feed.

Custom Hauling Characteristics

Custom haulers delivered 205,550 bushels of grain, or 9.1 percent of total marketings to country elevators in 1973 (Table 5). As could be expected, the volume of custom hauled grain followed production trends with hard red spring and durum wheat constituting the bulk of such grain movements. Custom hauled wheat comprised 66 percent of all custom hauled grain.

Of the 130 farms in the survey, 28 reported that they had some grain custom hauled. Rates for hauling custom grain ranged from a high of 12 cents a bushel to a low of 3½ cents a bushel with the average for all grain custom hauled being 6.15 cents per bushel (Table 6). The total cost for custom hauling was $12,649 for an average of $93 per farm in the survey (Table 6). The average cost per farm for only those farms which incurred such expenses was $452.

TABLE 5. CUSTOM HAULED AND FARM TRUCKED GRAIN DELIVERED TO LOCAL ELEVATORS OF FARMS ANSWERING QUESTIONNAIRE, 1973

Crop	Grain Delivered by Farm Truck	Grain Custom Hauled	Total Grain Delivered to Elevator	Percent of Total Grain Custom Hauled
	(bushels)	(bushels)	(bushels)	(percent)
All Wheat	1,548,562	135,196	1,683,758	8.0
Barley	263,487	12,583	276,070	4.6
Oats	194,342	45,000	239,342	18.8
Flax	36,378	5,371	41,749	12.9
Rye	16,550	7,400	23,950	30.9
Total	2,059,319	205,550	2,264,869	9.1

TABLE 6. RATES AND COSTS FOR CUSTOM HAULED GRAIN REPORTED IN QUESTIONNAIRES, 1973

Crop	Grain Custom Hauled	Average Rate Charged		Number of Farms	Total Cost	Cost Per Farm for All Farms in Study
		Weighted	Simple			
	(bushels)	(cents)	(cents)		(dollars)	(dollars)
All Wheat	135,196	6.06	6.38	26	8,197.70	63.06
Barley	12,583	7.42	6.90	5	934.15	7.19
Oats	45,000	5.13	6.63	4	2,310.00	17.77
Flax	5,371	5.93	5.00	2	318.66	2.45
Rye	7,400	12.00	12.00	1	888.00	6.83
Total	205,550	6.15	6.55	28	12,648.51	93.30

[a]Individual number of farms do not add up to total because some farms had more than one grain custom hauled.

Farm Managers' Considerations in Selecting a Country Elevator

A farm manager considers several factors when selecting an elevator with which to do business. Such factors include, but are not necessarily limited to: (1) distance to elevator; (2) price; (3) road conditions; (4) the services that an elevator offers; (5) the railway service offered to the elevator; and, (6) the services of the town in which the elevator is located. These factors and/or other factors determine whether a farm operator will market grain at the nearest delivery point or market grain at some more distant delivery point.

Ninety farm managers out of 130 replied that they normally deliver grain to the nearest country elevator. Forty of the farm managers, 30.8 percent, replied that they normally do not deliver to the nearest elevator (Table 7). The most prominent reason given by those who did not deliver to the nearest elevator was that the price was usually lower. Poor elevator service and poor railway service were the second most important reasons given by farm managers who did not normally deliver grain to the nearest elevator. Five farm managers replied that poor roads was the reason they did not deliver to the nearest elevator and ten farm managers replied that the town in which the nearest elevator was located lacked other needed services.

Farm managers who normally deliver to the nearest elevator listed poor railway service as the most prevalent reason why they occasionally deliver to more distant elevators.

TABLE 7. CONSIDERATIONS IN SELECTING A COUNTRY ELEVATOR

Item	Farm Managers Who Normally Do Not Deliver Grain to Nearest Elevator	Farm Managers[a] Who Normally Do Deliver Grain to Nearest Elevator	Total
Number of Farms	40	90	130
Reasons Given Why Farm Operators Normally or Occasionally Deliver Grain to More Distant Elevator			
1. Price is Usually Lower	17	8	25
2. Poor Roads	5	2	7
3. Poor Elevator Service	12	2	14
4. Poor Railway Service	12	16	28
5. Town Too Small, Lacks Other Needed Services	10	2	12
6. Other[b]	4	3	9

[a] Farm managers who normally deliver to the nearest elevator reported that they occasionally will deliver to a more distant elevator for the reasons listed in the table.

[b] Other reasons given for not delivering to the nearest elevator and number of replies are: inadequate storage, 4; nearest elevator did not handle flax, 1; elevator was not a cooperative, 1; and elevator took too much dockage, 1; respectively.

Eight farm managers replied that price was the factor which influenced them to deliver to more distant delivery points.

The most common reason listed for not delivering to the nearest elevator by all farm managers was poor railway service with price being listed as the second most common reason. Fourteen farm managers indicated poor elevator service and twelve, town too small, lacks other needed services as reasons for not delivering to their nearest elevator.

Characteristics of Grain Transportation

Farm Truck Characteristics

The average year of farm trucks included in the survey was a 1959 model (15 years old). The average truck had been purchased in 1964 at an average cost of $3,117. A majority of the trucks in the survey (68 percent or 132 trucks) were used when purchased. Only 61 trucks were new when purchased. The average current value of all trucks was $2,616.

With respect to the size of truck, the average box capacity of the 193 trucks was 275 bushels. In terms of tonnage, the average size was 1.9 tons. The average load carried by the trucks was 248 bushels, or 90 percent of capacity.

The average truck used in transporting grain traveled more miles for other activities such as hauling building materials, livestock and seed than it did in transporting grain from farm to local market. Total miles traveled averaged 2,510 for all trucks in the survey. Grain miles was reported as 31 percent of total annual miles (776 miles).

Characteristics of Grain Movements

The average farm truck used for transporting grain to local elevator made 40 trips to the delivery point during 1973. The average one-way distance to the local elevator for all farms was 9.6 miles, resulting in a total of 384 miles traveled while loaded.

The average time required for a truck to make one trip was 1 hour and 40 minutes, which included loading and unloading time, waiting time at the elevator and driving time. Loading time averaged 26 minutes, unloading time at the delivery point averaged 12 minutes, and an average of 20 minutes was reported for waiting to be unloaded at the elevator. Driving time averaged 42 minutes at an average speed of 36 miles per hour.

Costs of Transporting Grain by Farm Truck

Total Costs of Grain Transportation

The total cost of transporting grain from farm to local market is defined as the out-of-the-pocket costs, and fixed costs, including some imputed costs, incurred during the 1973 crop year for moving all grain to local market. Per farm costs can be calculated by multiplying the average total cost per truck by the average number of trucks per farm, 1.48. All cost components except driving and dead-haul labor have been weighted by a cost factor indicative of the percentage of total farm truck annual miles which were utilized in hauling grain. Thus, for example, depreciation computed is not the depreciation for the truck in 1973, but only that portion of the depreciation attributable to transporting grain from farm to market.

Total average cost per truck for transporting grain from farm to local elevator was calculated at $419.15 (Table 8). Fixed costs accounted for 32.9 percent of total costs or $137.95 (Table 8). Interest on investment was the most significant component of fixed costs accounting for 15.7 percent of total costs. Average licensing costs was $33.80 of which $12.16 was apportioned to trucking grain. Insurance and housing costs per truck were $13.95 and $10.37, respectively.

Variable operating costs were the most significant component of total costs accounting for 67.1 percent of total costs and averaging $281.20 per truck. Driving and dead-haul labor were the largest component of operating costs totaling $165.86, or 39.6 percent of total costs. Fuel was the second most significant operating cost and totaled $43.88 per truck. Tire and battery costs, repair costs, and lubrication costs averaged $25.68, $13.75 and $9.51 per truck, respectively. The remaining cost items including tune-ups, engine overhauls, repair labor and other costs totaling $22.52 per truck representing 5.4 percent of total costs.

The average total cost per farm in the survey for transporting grain from farm to local elevator was $620.34 based on a total cost per truck of $419.15 and an average of 1.48 trucks per farm.

TABLE 8. AVERAGE TOTAL COSTS OF TRANSPORTING GRAIN BY FARM TRUCK FROM FARM TO LOCAL MARKET[a]

Cost Item	Dollar Costs	Costs as a Percent of Total Cost
	(dollars)	(percent)
Fixed Costs		
Depreciation	35.59	8.5
Interest	65.88	15.7
License	12.16	2.9
Insurance	13.95	3.3
Housing	10.37	2.5
Total Fixed Costs	137.95	32.9
Variable Costs		
Lubrication	9.51	2.3
Fuel	43.88	10.5
Tires & Batteries	25.68	6.1
Tune-ups	3.80	.9
Repairs	13.75	3.3
Engine Overhauls	9.99	2.4
Repair Labor	7.70	1.8
Driving & Dead-Haul Labor	165.86	39.6
Other	1.03	.2
Total Operating Costs	281.20	67.1
TOTAL COSTS	419.15	100.0

[a]All costs are weighted by grain miles as a percent of total miles when appropriate.

Unit Costs of Grain Transportation

The unit costs considered were the bushel-mile, the bushel, and the grain mile.[9] The costs calculated are average fixed cost, average variable costs and average total costs.

Average total cost per bushel-mile was calculated at 0.6662 cents and was composed of 0.1832 cents of fixed costs and 0.4830 cents of variable costs (Table 9).

The average total cost per bushel was computed to be 4.95 cents and was composed of 1.52 cents of fixed costs and 3.43 cents of variable costs.

The average total cost per grain mile was calculated at 71.84 cents. This cost was made up of 20.68 cents for fixed costs and 51.16 cents for variable costs.

---

[9] See footnote number 7, p. 35, for a precise definition of these units.

TABLE 9. AVERAGE UNIT COSTS OF TRANSPORTING GRAIN BY FARM TRUCK FROM FARM TO LOCAL MARKET

Item	Average Fixed Cost	Average Operating Cost	Average Total Cost
	(cents)	(cents)	(cents)
Bushel-Mile	0.1832	0.4830	0.6662
Bushel	1.52	3.43	4.95
Grain Mile	20.68	51.16	71.84

CHAPTER 5

IMPACT OF SELECTED FACTORS ON THE COST OF TRANSPORTING GRAIN BY FARM TRUCK

Chapter 5

IMPACT OF SELECTED FACTORS ON THE COST OF TRANSPORTING GRAIN BY FARM TRUCK

Several factors have potential impacts on the bushel-mile cost of moving grain from farm to local elevator. The factors selected for analysis in this study include box size, truck tonnage, annual truck mileage, bushels hauled, bushel-miles, age of truck, elevator distance and farm size. The impact that each factor had on transportation costs was determined by utilizing a stratification scheme for each factor.

Size of Truck

Two general measures of truck size are used to determine the impact of truck size on the transportation costs incurred in moving grain from farm to local market. The two measures utilized were truck box size and truck tonnage.

Size of Truck Box

There is a negative relationship between the size of the truck box and the average cost per bushel-mile of moving grain. That is, as the size of the box increased, the per unit costs decreased (Figure 4). The cost per bushel-mile for the smallest box size stratification considered, 150 bushels or less, was 1.24 cents which was the highest cost for all stratifications (Table 10). The lowest cost occurred

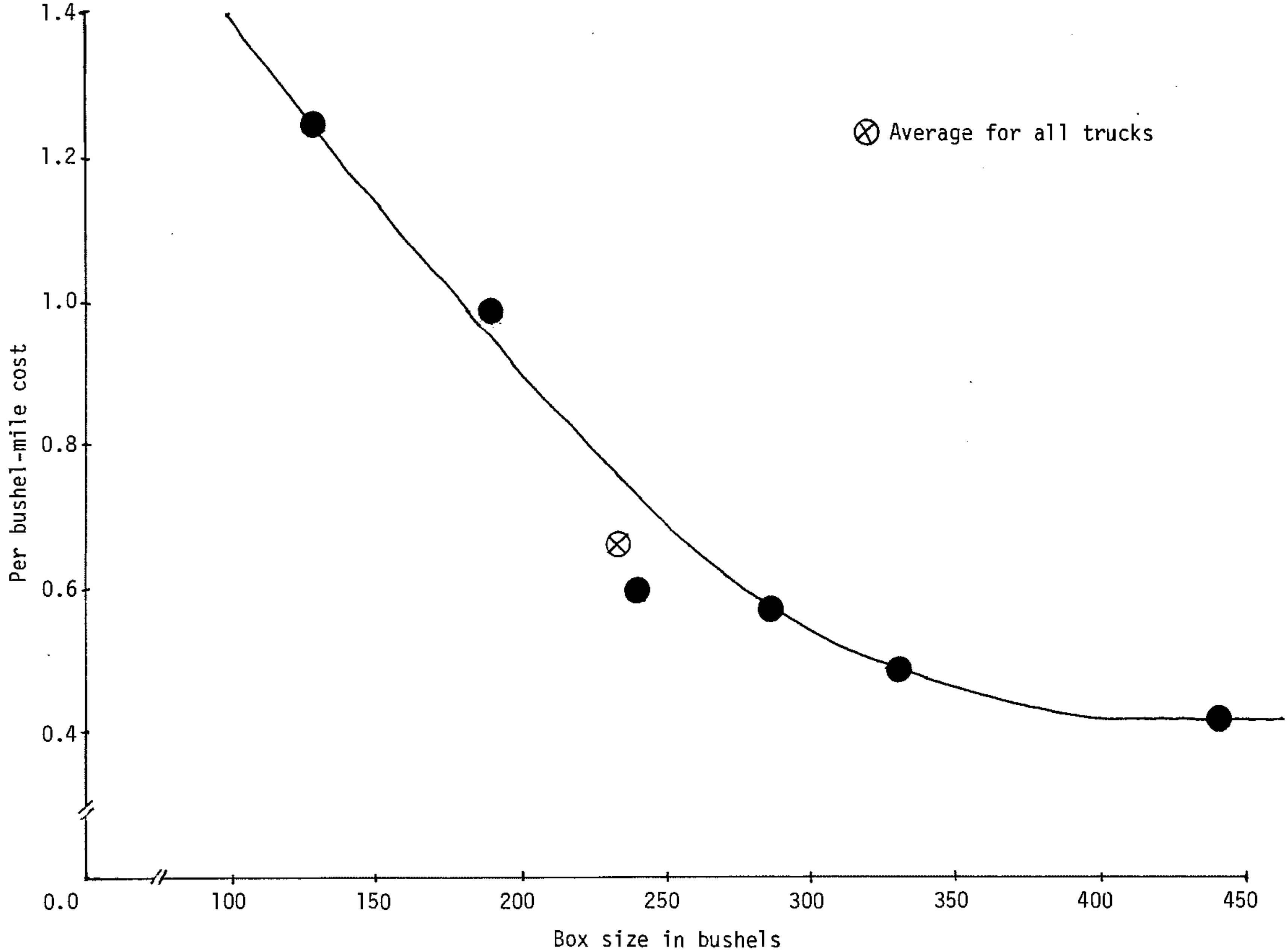

Figure 4. Relationship Between Truck Box Size and Bushel-Mile Costs.

TABLE 10. RELATIONSHIP BETWEEN AVERAGE COST PER BUSHEL-MILE OF GRAIN TRANSPORTATION AND THE TRUCK BOX SIZE

Item	Unit of Measurement	Capacity of Truck Box in Bushels						
		150 and Less	151-200	201-250	251-300	301-350	350 and Greater	All Trucks
Number in Sample		19	18	37	70	34	15	193
Average Cost/Bushel-Mile	cents	1.2435	.9816	.6092	.5828	.5083	.4442	.6662
Average Fixed Cost/Bushel-Mile	cents	.3419	.2167	.1494	.1517	.1818	.1748	.4830
Average Variable Cost/Bushel-Mile	cents	.9015	.7648	.4598	.4311	.3265	.2694	.1832
Average Load Carried	bushels	136	195	225	264	277	368	248
Total Bushel-Miles		1,112,579	712,546	3,360,840	8,612,940	6,535,202	24,787,487	7,021,922
Average Total Grain Miles	miles	441	280	664	935	848	1,165	776
Average Box Size	bushels	131	190	242	289	333	441	275

at the largest box size stratification of 350 bushels or greater, where the cost was .44 cents per bushel-mile. The average load carried by trucks in the smallest stratification was 136 bushels and for trucks in the largest stratification, 368 bushels.

The negative relationship between box size and cost per bushel-mile is not due to the box size itself but rather the amount of grain handled and the miles driven in hauling that grain and certain other operating aspects. The average fixed costs reach the lowest point at an average box size of 242 bushels, and increase slightly thereafter to a point much less than the fixed cost for the smallest box size considered (Table 10). This is probably due to decreasing fixed costs per bushel of capacity and the fact that ownership of a larger truck is usually indicative of the amount of grain to be handled and/or the distance to the delivery point, both of which would have a significant effect on the fixed bushel-mile costs.

The variable bushel-mile costs showed a generally negative relationship with box size throughout the entire stratification. This relationship can be partially explained by the fixed nature of driving labor, a significant portion of operating costs. Assuming that the same time would be required to drive a large or small capacity truck to the delivery point, the cost per bushel-mile for driving labor will be less for a larger truck than for a smaller truck.

Also, other operating requirements such as fuel consumption may increase at a lesser rate than capacity, thus leading to reduced cost per unit of output for the larger truck.

Truck Tonnage

The relationship between truck size as measured in tonnage and the average cost per bushel-mile was also generally negative (Figure 5). Five stratification levels were used: 1.0 tons or less, 1.5 tons, 2.0 tons, 2.5 tons and 3.0 tons and greater. The lowest cost per bushel-mile of 0.43 cents occurred at the 3.0 ton and greater truck size (Table 11). The highest cost per bushel-mile was found at the smallest truck size, 1.0 ton or less, with a cost of 1.18 cents. The negative relationship between truck tonnage and cost per bushel-mile is not due entirely to the size of the truck but also the decreasing nature of fixed costs as the truck size increases while total bushel-miles increase.[10] This can be seen by inspecting the changes in fixed costs per bushel-mile between the 2.0 ton and 2.5 ton stratifications where fixed costs per bushel-mile increase from .17 cents to .20 cents. The noted difference from the general relationship can be explained by total bushel-miles accumulated for the two stratifications: Trucks included in the 2.0 ton stratification accumulated 6,811,604 bushel-miles which is greater

---

[10]One would assume that a rational farm manager would purchase a larger truck if the number of bushels hauled and/or the distance to the delivery point increased, assuming that he did not have sufficient capability with the existing truck to deliver his grain. As such, one would expect that the larger the truck the greater the number of bushel-miles that would be accumulated.

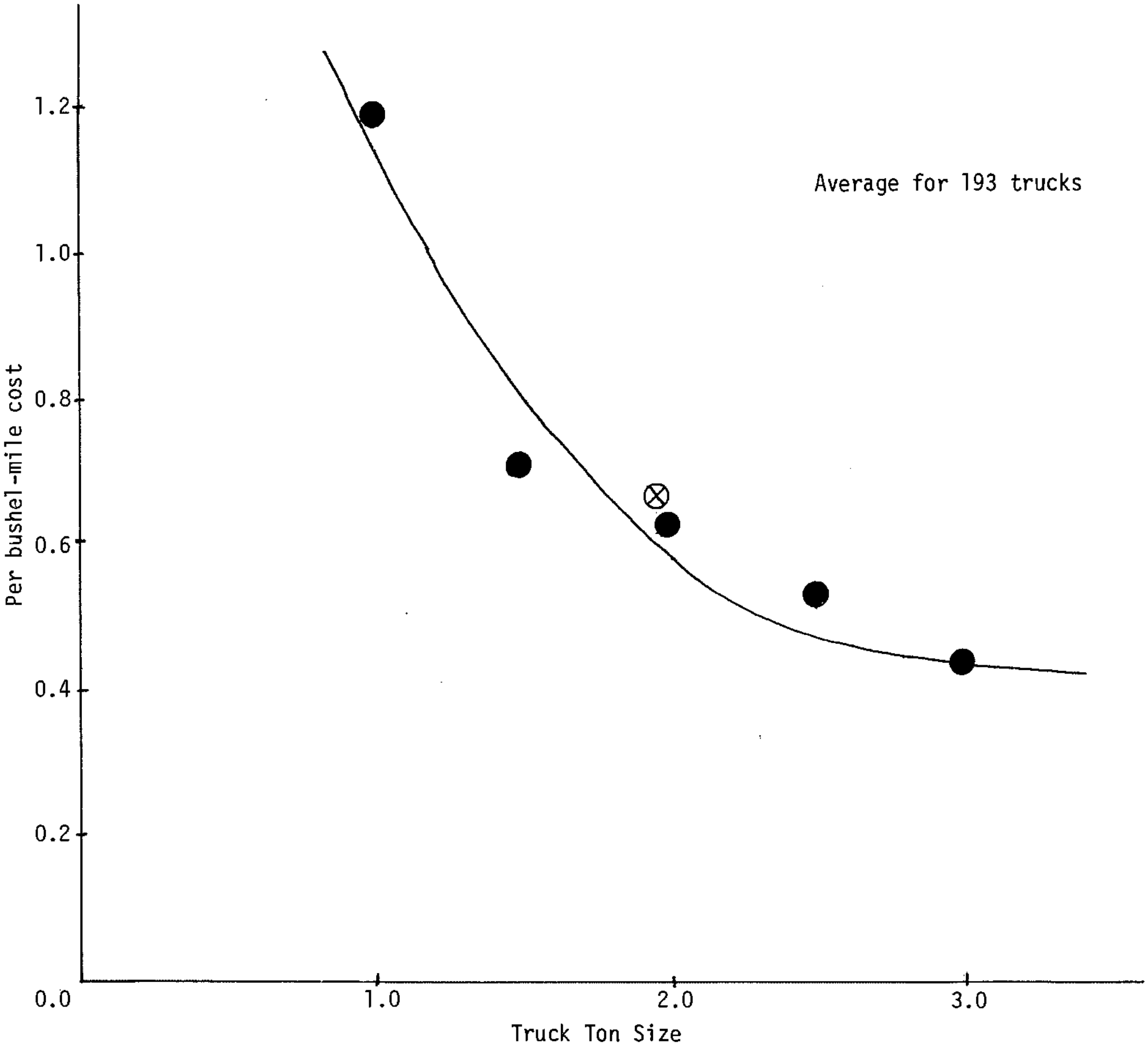

Figure 5. Relationship Between Truck Tonnage and Bushel-Mile Costs.

TABLE 11. RELATIONSHIP BETWEEN THE AVERAGE COST PER BUSHEL-MILE OF GRAIN TRANSPORTATION AND THE SIZE OF THE TRUCK

Item	Unit of Measurement	Truck Size (tons)					
		1.0 Ton or Less	1.5 Ton	2.0 Ton	2.5 Ton	3.0 Ton or Greater	All Trucks
Number in Sample		16	28	128	15	6	193
Average Size of Truck	tons	.98	1.5	2.0	2.5	3.0	1.92
Average Cost/Bushel-Mile	cents	1.1800	.7034	.6214	.5254	.4307	.6662
Average Fixed Cost/Bushel-Mile	cents	.3466	.1622	.1671	.2015	.1420	.4830
Average Variable Cost/Bushel-Mile	cents	.8334	.5412	.4543	.3239	.2888	.1832
Average Load Carried	bushels	138	209	261	273	380	248
Total Bushel-Miles		1,065,660	2,255,159	6,811,604	6,038,818	52,094,718	7,021,922
Average Total Grain Miles	miles	434	546	812	772	1,998	776
Average Box Size	bushels	130	215	287	370	442	275

than the 6,038,818 bushel-miles experienced by trucks included in the 2.5 ton stratification.

Variable costs followed the inverse relationship throughout the entire stratification, decreasing as truck size increased. This can be attributed to the nature of driving labor and to the rate at which capacity increases versus the rate at which variable costs increase.[11]

Utilization of Truck

Total Annual Miles

As total annual truck miles increased, the bushel-mile cost for transporting grain decreased (Figure 6). This general inverse relationship existed throughout the entire stratification of 0 to 1,000 miles, 1,001 to 2,000 miles, 2,001 to 3,000 miles, 3,001 to 5,000 miles and 5,000 miles and greater (Table 12). Total average cost per bushel-mile ranged from a high of 1.11 cents to a low of .27 cents. The utilization of the truck for hauling grain decreased as the total annual miles of the truck increased. Also, as total annual miles increased, the number of grain miles increased. This would seem to indicate that the trucks with greater annual miles delivered to more distant markets and/or hauled more grain than smaller trucks.

Total Bushels Hauled

The relationship between total bushels hauled and the average total bushel-mile cost was generally negative, although

[11]Driving labor is fixed per trip: as such, as the capacity increases the driving labor costs per bushel or bushel-mile decreases.

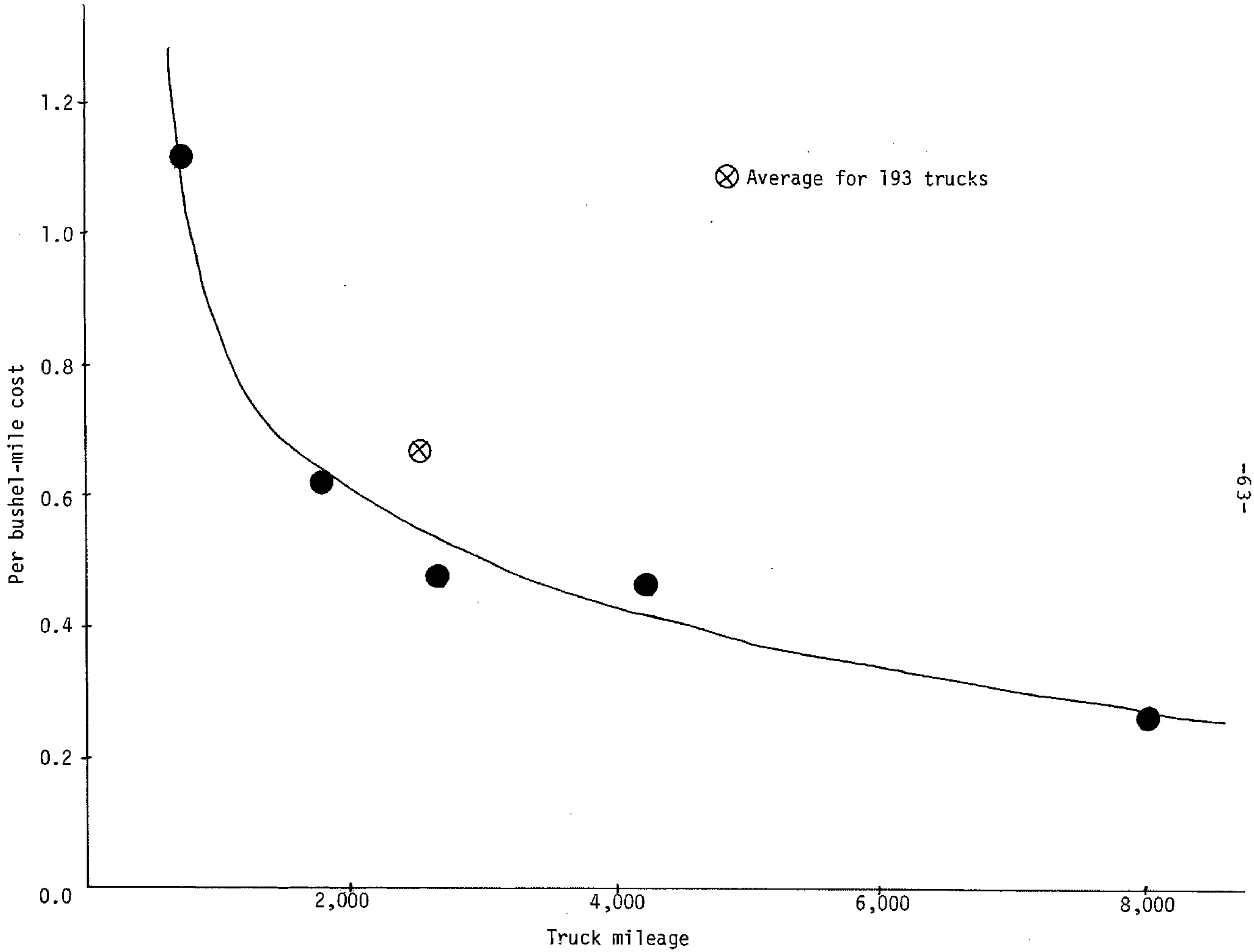

Figure 6. Relationship Between Annual Truck Miles and Average Bushel-Mile Costs.

TABLE 12. RELATIONSHIP BETWEEN GRAIN TRANSPORTATION COSTS AND TRUCK MILEAGE

Item	Unit of Measurement	Annual Truck Mileage (miles) 0 to 1,000	1,001 to 2,000	2,001 to 3,000	3,001 to 5,000	5,001 and Greater	All Trucks
Number in Sample		47	69	28	37	12	193
Average Annual Truck Mileage	miles	738	1,778	2,657	4,213	8,073	2,510
Average Cost/Bushel-Mile	cents	1.1098	.6149	.4776	.4697	.2697	.6662
Average Fixed Cost/Bushel-Mile	cents	.3455	.1667	.0993	.1169	.0419	.4830
Average Variable Cost/Bushel-Mile	cents	.7643	.4482	.3783	.3528	.2279	.1832
Average Annual Grain Miles	miles	305	664	764	1,181	2,040	776
Grain Miles as a Percent of Total Miles	percent	41	37	29	28	25	31

it was slightly irregular at different stratifications (Figure 7). The highest total average cost was 1.18 cents per bushel-mile for those trucks which hauled 2,000 bushels or less (Table 13). The lowest cost was 0.37 cents per bushel-mile which was experienced by those trucks which hauled between 15,001 and 20,000 bushels. Total grain transportation costs increased throughout the stratifcations, from $106.88 per truck to $1,002.13 per truck. The rate at which total costs increase versus the rate at which bushels hauled increases and grain miles increase, gives some insight to the variation of costs between stratification. Between the stratification of 8,001 to 10,000 bushels and 10,001 to 15,000 bushels, costs increased from 0.50 cents per bushel-mile to 0.57 cents per bushel-mile while at the same time bushels hauled increased from 9,196 to 12,603.

Bushel-Miles

The most appropriate truck utilization measure is the bushel-mile. The use of the bushel-mile as a means of measuring impacts on the per bushel-mile cost weights the miles traveled in transporting grain and the bushels hauled, both of which have important effects on the cost of transporting grain. Thus, the bushel-mile factor combines the previous two factors of bushels hauled and total annual miles into one affect. Although the total annual miles are distinct from grain miles the effect of changes should be similar.

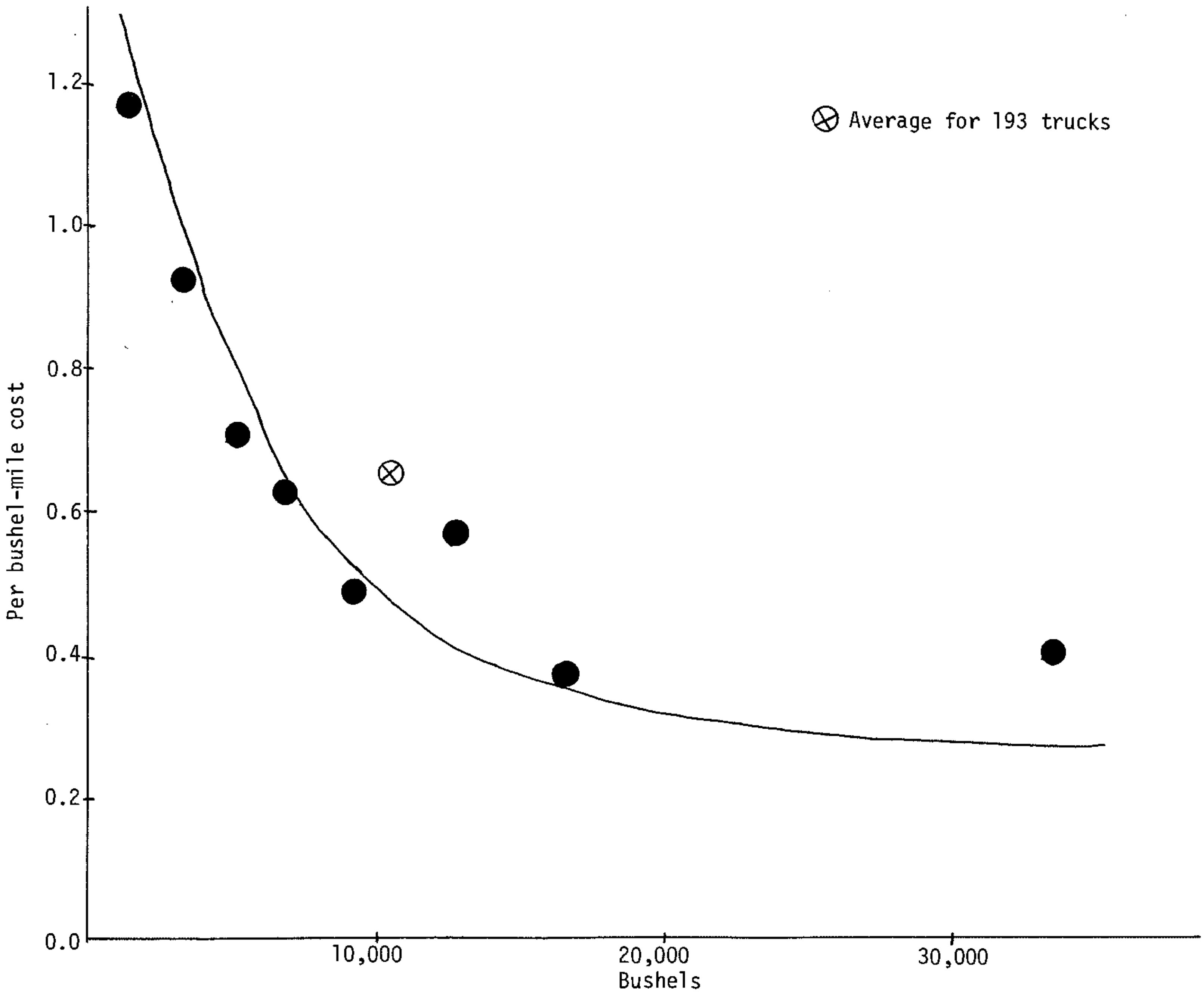

Figure 7. Relationship Between Total Bushels Hauled and Average Bushel-Mile Costs.

TABLE 13. RELATIONSHIP BETWEEN THE BUSHELS TRUCKED TO LOCAL MARKET AND TRUCKING COSTS

Item	Unit of Measurement	Bushels: 2,000 or Less	2,001 to 4,000	4,001 to 6,000	6,001 to 8,000	8,001 to 10,000	10,001 to 15,000	15,001 to 20,000	20,001 and Greater	All Trucks
Number in Sample		16	32	28	21	23	35	18	20	193
Average Bushels Transported	bushels	1,362	3,193	5,196	6,950	9,196	12,603	16,777	33,460	10,565
Average Cost/Bushel-Mile	cents	1.1827	.9379	.7126	.6408	.4976	.5743	.3708	.4006	.6662
Average Fixed Cost/Bushel-Mile	cents	.2482	.2968	.1941	.1545	.1510	.1587	.1155	.1047	.4830
Average Variable Cost/Bushel-Mile	cents	.9344	.6411	.5185	.4864	.3466	.4156	.2553	.2959	.1832
Total Grain Transportation Costs	dollars	106.88	208.43	281.52	311.20	421.71	513.13	577.41	1,002.23	419.14
Average Annual Grain Miles	miles	164	336	575	494	793	897	1,218	1,917	776

A very distinct inverse relationship was found between the total number of bushel-miles and the total average per bushel-mile cost (Figure 8). The highest average cost of 1.57 cents per bushel-mile was noted for those trucks accruing 15,000 or less bushel-miles annually (Table 14). The lowest cost noted was 0.28 cents per bushel-mile incurred by those trucks accruing more than 170,000 bushel-miles annually. Average total per bushel-mile costs decreased throughout all stratifications as did average fixed costs and average variable costs.

As bushel-miles increased, one-way distance to the elevator increased. This might be expected because it is doubtful that there is any direct relationship between the number of bushels produced and distance to delivery point.

Age of Truck

A rather insignificant relationship exists between the age of the truck and average total per bushel-mile costs (Figure 9). While a generally positive relationship does exist between the age of the truck and the average total per bushel-mile cost; this trend was slight relative to other factors considered. Costs fluctuate throughout the stratifications (Table 15).

The relationship was positive in nature showing that as the age of the truck increased, the cost per bushel-mile increased. The highest cost of 0.91 cents per bushel-mile was observed at the 1951-55 stratification. The lowest

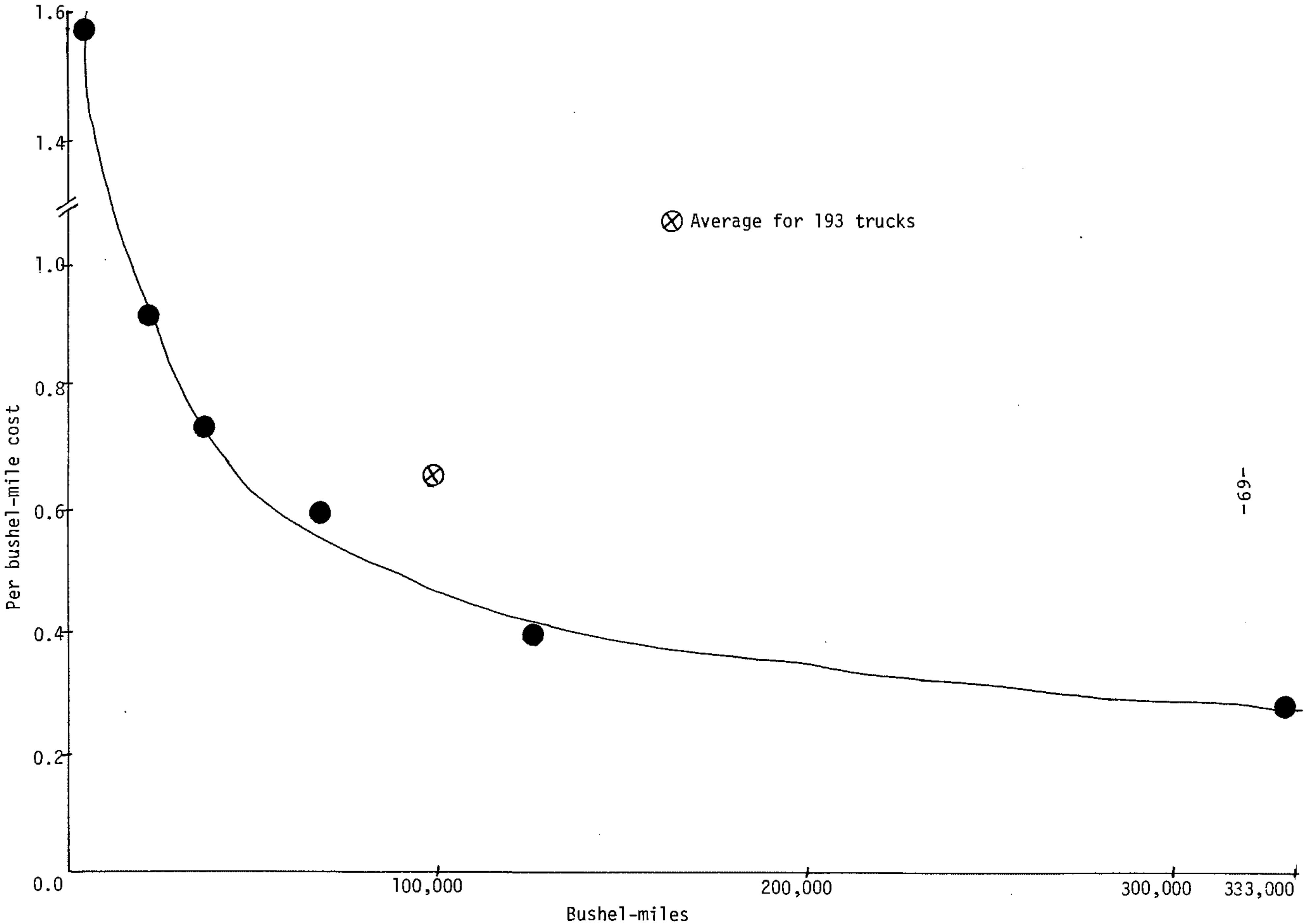

Figure 8. Relationship Between Bushel-Miles and Average Bushel-Mile Cost.

TABLE 14. RELATIONSHIP BETWEEN THE COST OF TRANSPORTING GRAIN BY FARM TRUCK TO LOCAL MARKET AND THE TOTAL BUSHEL-MILES ACCUMULATED

Item	Unit of Measurement	Bushel-Miles: 15,000 or Less	15,001 to 30,000	30,001 to 50,000	50,001 to 90,000	90,001 to 170,000	170,001 or Greater	All Trucks
Number in Sample		19	32	29	43	40	30	193
Average Total Bushel-Miles		7,181	22,365	38,239	70,397	129,666	333,354	104,536
Average Cost/Bushel-Mile	cents	1.5692	.9100	.7076	.5807	.3960	.2769	.6662
Average Fixed Cost/Bushel-Mile	cents	.3094	.2676	.1844	.1830	.1199	.0965	.4830
Average Variable Cost/Bushel-Mile	cents	1.2598	.6425	.5232	.3977	.2762	.1804	.1832
Total Grain Transportation Costs	dollars	86.46	200.18	263.77	407.64	506.37	913.77	419.14
One-Way Distance to Elevator	miles	3.5	7.3	9.1	8.5	12.2	14.6	9.6
Average Load Carried	bushels	234	180	214	248	276	324	248
Average Number of Trips		17	25	30	41	45	75	40

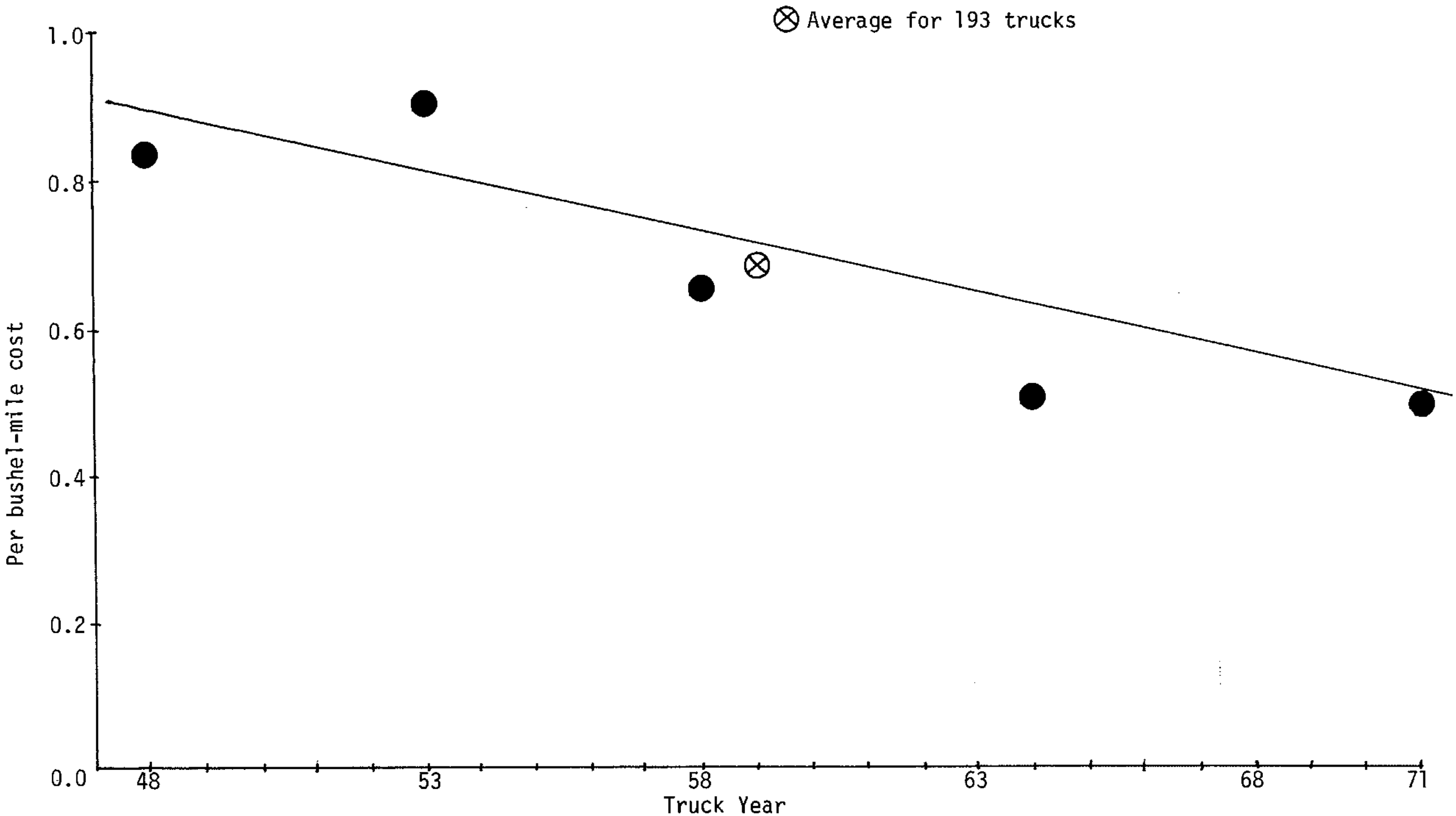

Figure 9. Relationship Between Truck Year and Average Bushel-Mile Cost.

TABLE 15. RELATIONSHIP BETWEEN GRAIN TRANSPORTATION COST BY FARM TRUCK AND THE YEAR OF THE TRUCK

Item	Unit of Measurement	Year of Truck					
		1950 or Older	1951 to 1955	1956 to 1960	1961 to 1966	1966 or Newer	All Trucks
Number in Sample		37	28	49	52	27	193
Average Year of Truck		1948	1953	1958	1964	1971	1959
Average Cost/Bushel-Mile	cents	.8489	.9121	.6556	.5042	.4921	.6662
Average Fixed Cost/Bushel-Mile	cents	.1951	.2340	.1556	.1398	.2475	.4830
Average Variable Cost/Bushel-Mile	cents	.6538	.6781	.5000	.3644	.2447	.1832
Total Grain Transportation Costs	dollars	255.25	256.56	430.95	428.00	773.84	419.14
Total Bushels Transported	bushels	5,244	5,624	10,777	12,558	18,764	10,566
Size of Truck	tons	1.7	1.8	1.9	2.1	2.2	1.9
Average Load Carried	bushels	204	213	240	275	306	248
Annual Total Miles	miles	1,568	1,694	2,494	3,218	3,314	2,510
Annual Grain Miles	miles	535	446	800	901	1,162	776
Total Bushel-Miles		53,132	47,231	99,655	122,885	207,923	104,536

cost was observed for the newer trucks, 1966 or newer, which had a cost of 0.49 cents per bushel-mile.

One-Way Distance to Elevator

The relationship between the per bushel-mile average total cost of transporting grain by farm truck and the one-way distance to the elevator was negative (Figure 10). That is, as the distance to the elevator increased the per bushel-mile cost decreased. Such a relationship would be expected because of the relationship which exists between truck utilization and costs. Given that two trucks transport the same amount of grain, the truck which has the greatest delivery distance will also have the greatest utilization and thus the lower per bushel-mile cost.

The highest cost was incurred for those trucks which delivered 4.0 miles or less to a local elevator (Table 16). The lowest cost, 0.32 cents per bushel-mile, was experienced by those trucks which were located farthest from the local elevator. The trend was uniform throughout the stratification with costs decreasing as distance to elevator increased. Both fixed and variable costs followed the same trend as total average costs.

The average size of truck was the same for all distance stratifications except for the 12.1 to 16.0 mile range. Also, the number of bushels transported was similar except for the 12.1 to 16.0 mile range.

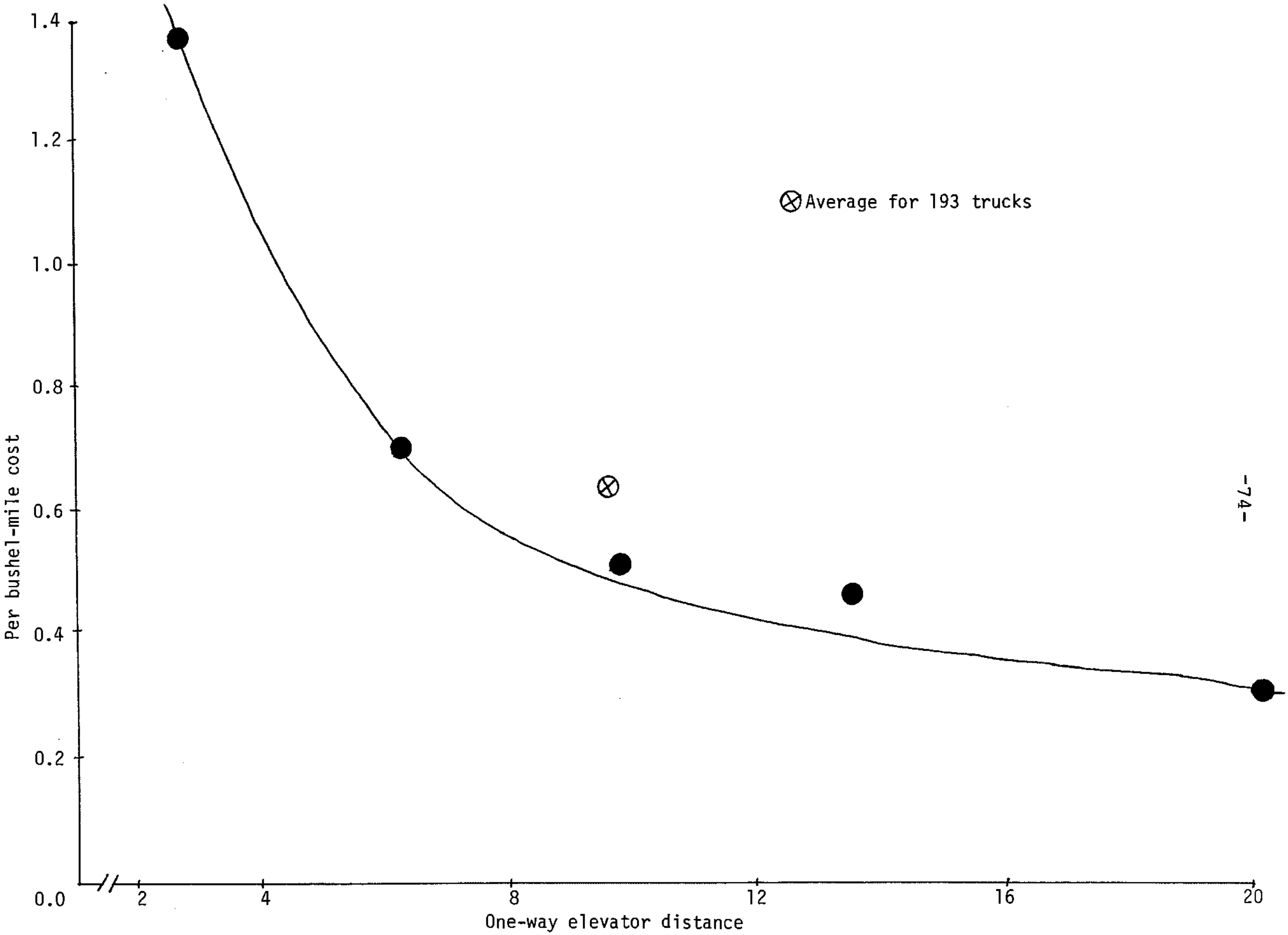

Figure 10. Relationship Between One-Way Elevator Distance and Average Bushel-Mile Costs.

TABLE 16. RELATIONSHIP BETWEEN THE DISTANCE TO ELEVATOR AND TRANSPORTATION COSTS BY FARM TRUCK

Item	Unit of Measurement	One-Way Distance to Elevator (miles) 4.0 or Less	4.1 to 8.0	8.1 to 12.0	12.1 to 16.0	16.0 or Greater	All Trucks
Number in Sample		28	54	56	32	23	193
One-Way Distance to Elevator	miles	2.6	6.3	9.7	13.5	20.2	9.6
Average Cost/Bushel-Mile	cents	1.3712	.6999	.5293	.4809	.3200	.6662
Average Fixed Cost/Bushel-Mile	cents	.2526	.2153	.1584	.1745	.0953	.4830
Average Variable Cost/Bushel-Mile	cents	1.1187	.4845	.3709	.3064	.2247	.1832
Total Bushels Transported	bushels	9,832	8,483	11,638	13,567	9,564	10,566
Average Number of Trips		41	37	46	39	38	40
Annual Total Miles	miles	1,706	2,139	2,591	2,426	4,282	2,510
Annual Grain Miles	miles	230	465	888	1,052	1,511	776
Size of Truck	tons	1.9	1.9	1.9	2.1	1.9	1.9

Farm Size

As was the case in the truck age factor, the relationship between farm size and per bushel-mile grain transportation costs was negligible (Figure 11). A slight negative relationship existed throughout the stratifications. The highest average per bushel-mile cost existed at the farm size of 1,352 acres, which is near the average farm size of 1,376 acres (Table 17). The lowest cost was found at the next to largest average farm size of 2,096 acres, with a cost of 0.45 cents per bushel-mile.

The degree of variation throughout the stratifications would indicate that farm size does not significantly affect the per bushel-mile cost of transporting grain from farm to local market.

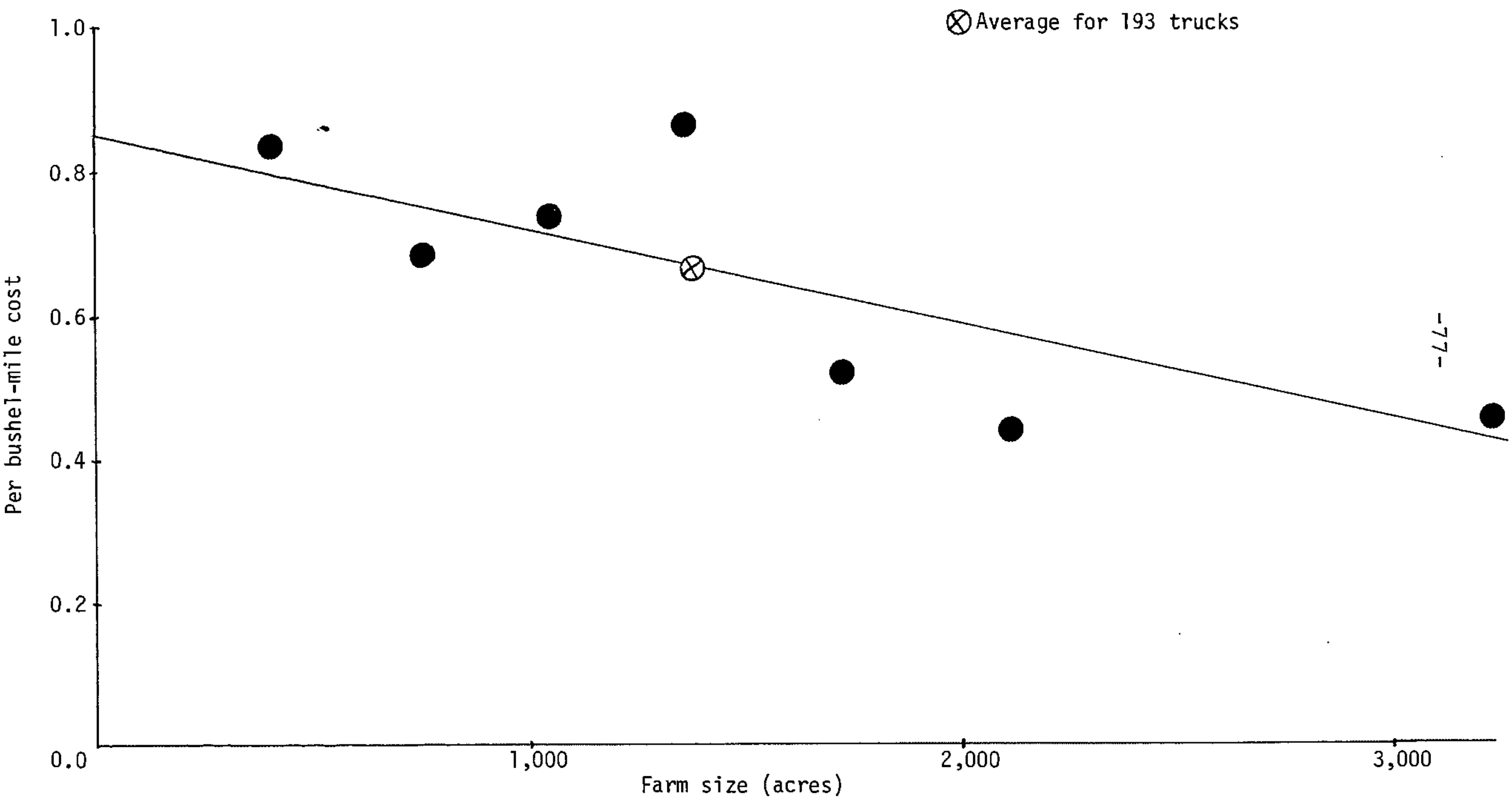

Figure 11. Relationship Between Farm Size and Average Bushel-Mile Costs.

TABLE 17. RELATIONSHIP BETWEEN THE COST OF TRANSPORTING GRAIN BY FARM TRUCK AND FARM SIZE

Item	Unit of Measurement	Farm Size (acres)							All Trucks
		600 or Less	601 to 900	901 to 1,200	1,201 to 1,500	1,501 to 1,900	1,901 to 2,400	2,401 or Greater	
Number in Sample		15	40	46	28	24	19	21	193
Average Size of Farm	acres	409	757	1,055	1,352	1,716	2,096	3,225	1,376
Average Cost/Bushel-Mile	cents	.8380	.6810	.7377	.8661	.5202	.4478	.4567	.6662
Average Fixed Cost/Bushel-Mile	cents	.2652	.1587	.2062	.2415	.1539	.1287	.1258	.4830
Average Variable Cost/Bushel-Mile	cents	.5728	.5224	.5315	.6246	.3663	.3191	.3309	.1832
Total Grain Transportation Costs	dollars	243.46	355.98	376.73	366.89	490.27	410.61	791.72	419.14
Size of Truck	tons	1.5	1.8	2.0	2.0	1.9	2.0	2.2	1.9
One-Way Distance to Elevator	miles	10.0	10.5	9.0	8.1	9.8	11.3	9.0	9.6
Total Bushels Transported	bushels	3,956	8,008	8,689	9,780	11,232	10,516	24,602	10,566
Annual Grain Miles	miles	479	794	629	552	1,005	819	1,273	776
Annual Total Miles	miles	1,912	2,691	2,093	2,069	3,312	2,677	3,030	2,510

CHAPTER 6

SUMMARY, CONCLUSION, AND IMPLICATIONS

Chapter 6

SUMMARY, CONCLUSIONS AND IMPLICATIONS

A sample must be representative of a population if the various sample parameters are to be indicative of the population parameters. It cannot be shown if the sample of 193 trucks is representative of the population; however, the variation within the sample would seem to indicate that it is representative. The variation consists of the differences reported in truck size and utilization, distance to the elevator, age of the truck and farm size. It should be pointed out that sample averages would not necessarily indicate the situation for a given farm operator because of this variation. A more likely indicator for a given situation would be the parameters of a stratification which is similar to a farm manager's operation. However, a good deal of variation also occurs even within a stratification and caution must be used when adapting the results of this study to individual situations. The results are, however, believed to be consistent with the overall and average grain transportation activity of farm operators.

Summary and Conclusions

Characteristics of Grain Transportation

A total of 130 farms provided 1973 cost data for moving grain from farm to market for 193 trucks. Hard red spring and durum wheat were the dominant crop produced and correspondingly marketed by the farms in 1973. Production of wheat in 1973 totaled 1,679,988 bushels and marketings of wheat totaled 1,683,758 bushels.

Grain which was reported custom hauled from farm to local market consisted of 9.1 percent of total marketings, or 205,550 bushels. Of the 130 farms in the survey, 26 reported that they had some grain which was custom hauled. The average custom rate charged was 6.15 cents per bushel.

Ninety farm managers out of 130 reported that they normally deliver grain to the nearest elevator. Forty farm managers, 30.8 percent, did not deliver to the nearest elevator for various reasons. The most prominent reason given for not delivering to the nearest country elevator was that price was usually lower. Other reasons given in order of their frequency were poor elevator service, poor railway service, town too small, lacks other needed services, and poor roads.

The average year of trucks in the survey was a 1959 model with a corresponding age of 15 years. The average truck was used and purchased in 1964 at a price of $3,117. The average current value of all 193 trucks in 1973 was $2,616. Capacity of the average truck was 275 bushels and the trucks hauled an average load of 248 bushels, 90 percent of capacity. The average truck put on 2,510 miles annually, of which 776 miles were attributed to the hauling of grain from farm to market.

An average of forty trips were made to the local elevator from an average one-way distance of 9.6 miles.

Total Costs of Grain Transportation

The annual total average cost of transporting grain from farm to local elevator was $419.15 per truck for the trucks included in the study. Fixed costs accounted for 32.9 percent of total costs amounting to $137.95. Operating costs were the most significant component of total costs totaling $281.20 per truck.

The average total cost per farm for transporting grain from farm to local elevator was $620.34 for 1973. This total cost was based on the cost per truck of $419.15 and 1.48 trucks per farm.

The unit cost output measures considered were the bushel-mile, the bushel and the grain mile. Average total unit costs for the bushel-mile, bushel, and grain mile were .6662 cents, 4.95 cents and 71.84 cents, respectively. As was the case with total costs, operating costs comprised the most significant portion of unit costs.

Impact of Selected Factors on Costs

The factor of truck size, as measured in terms of box size and tonnage, affected transportation costs in a negative manner; that is, as truck size increased the per bushel-mile cost of transporting grain decreased. At least part of such an effect was due to the increased output of the larger trucks. Consistently, the larger trucks accumulated more bushel-miles than smaller trucks with the exception of one stratification.

The relationship between the utilization of the truck and the unit cost of transporting grain was also negative as expected for all three measrues of utilization -- bushels hauled, total annual miles, and bushel-miles. A very pronounced relationship was found between the per bushel-mile cost and the utilization of the truck in terms of bushel-miles. For each measure of utilization, per bushel-mile costs decreased as farm truck utilization increased.

The relationship between the age of the truck and per unit costs was not so nearly well defined as in other factors. At best, the relationship was slightly negative. This was not expected, it was thought that as the age of the truck increased, per unit costs would decrease.

Increasing elevator distance had the effect of reducing per unit costs; thus a negative relationship existed. This type of relationship was expected because of the increased utilization which takes place when elevator distance increases, everything else constant.

The relationship between the size of farm and per unit transportation costs was not negative as expected. There was little if any relationship exhibited at all by the farm size factor.

Implications

Labor Costs

Labor costs were the most significant component of total costs and as such posed significant implications with regard to increasing labor rates. As labor rates increase the cost of transporting grain from farm to local market may increase significantly. This, however, is based on the assumption that no excess labor capacity exists on the farm which has a fixed cost associated with it. If, for example, a farm manager employs hired labor which is paid for on a periodic salary basis, and that labor has excess capacity during certain times of the year which could be used for transporting grain, these increases in labor costs my not affect grain transportation costs.

Size of Truck and Utilization

The size of truck which a farm manager chooses to operate should be such that it allows him to market his grain with efficiency, in terms of time, and also allow a reasonable cost for transporting his grain from farm to local market. The two goals of marketing efficiency, in terms of time and reduced costs of transporting grain, are in direct opposition to each other. As the size of truck increases the capacity to move grain increases and as such reduces the time necessary to market a given amount of grain. However, the utilization of the truck decreases as truck size increases when handling a given amount of bushels, and thus, increased costs per unit would be experienced. Therefore, a trade-off exists between the size of truck a farm manager chooses and the amount of time which is available to move his grain to local market. Generally, one could conclude that a farm operator is better off with a larger truck if he has sufficient grain to transport. A sufficient amount of grain would consist of that quantity which leads to a level of utilization associated with a cost which is acceptable to the farm manager, given a specific distance to the elevator.

One-Way Distance to Local Eelvator

As the one-way distance to the elevator increases, the per unit costs decrease for transporting grain from farm to local market. Total costs, however, could increase or decrease depending on farm truck utilization which is dependent upon elevator distance and bushels transported. It may be generally assumed that while total costs will increase as elevator distance increases, per unit costs will decrease. Thus, as elevator numbers decrease and become more distant from farms, total grain transportation costs for farm operators will increase.

Age of Truck and Farm Size

Because of the non-existent or slight relationship which existed between age of truck and farm size, and transportation costs, one cannot realistically draw any implications.

APPENDIX A

APPENDIX A

CONFIDENTIAL

QUESTIONNAIRE ON COST AND METHODS OF MOVING GRAIN BY TRUCK IN NORTH DAKOTA

PLEASE LIST OR ESTIMATE ANSWERS AS ACCURATELY AS POSSIBLE.

1. Size of farm unit ______________ acres.

2. Production. Please estimate your crop production in 1973.

	Estimated Production (bushels)
wheat	____________________
durum	____________________
barley	____________________
oats	____________________
rye	____________________
flax	____________________
other, please specify	____________________
	____________________
	____________________

3. Volume of grain marketed and method of delivery during January, 1973 through December, 1973:

A)

Crop	Total bushels delivered to local elevators	Bushels of grain hauled by own truck to local elevators	Grain hauled by custom truck to local elevators	
--	bu.	bu.	bu.	rate charged/bu.
wheat				
durum				
barley				
oats				
rye				
flax				
other				

B) Distance from your primary grain storage facility to your first and second choice elevator or delivery point (one-way):

	FIRST CHOICE	SECOND CHOICE
total one-way distance	______________	______________

C) Annual number of grain marketing trips to:

first choice delivery point __________per year.

second choice delivery point__________per year.

D) Average time required per load to move grain from farm storage facility to delivery points:

	FIRST CHOICE	SECOND CHOICE	
1) loading	________	________	minutes
2) unloading	________	________	minutes
3) driving time (one-way)	________	________	minutes
4) waiting time	________	________	minutes
5) traveling speed	________	________	m.p.h.

E) How far is the elevator located nearest your farm? ________ miles.
Is the elevator you normally deliver your grain to the closest elevator to your farm? Yes_____ No_____

If you don't normally deliver your grain to your nearest elevator, why not? (Check one or more)

1) price is usually lower _____
2) poor roads _____
3) poor elevator service _____
4) poor railway service _____
5) town is too small, lacks other needed services _____
6) other, please specify __________
____
____

F) Percentage of your total annual truck mileage utilized in:

marketing grain ______________%
other: livestock marketing, feed and seed hauling, etc. ______________%

4. THE FOLLOWING ESTIMATES PERTAINING TO GRAIN TRUCKS AND GRAIN TRUCK COSTS SHOULD RELATE TO THIS ENTIRE PAST YEAR OF OPERATION (JANUARY, 1973 THROUGH DECEMBER, 1973).

Blank spaces relating to truck #2 is provided in the event that you haul grain with more than one truck.

A) Trucks	Truck #1	Truck #2
Size	________	________
Make	________	________
Year	________	________
Year of purchase	________	________
Price paid	$________	$________
Present value	$________	$________
Box capacity in wheat bushels	________ bu.	________ bu.
Average load carried in wheat bushels	________ bu.	________ bu.
Gross vehicle weight	________ G.V.W.	________ G.V.W.
Total miles driven annually	________ miles	________ miles
Miles per gallon of fuel	________ miles/gal	________ miles/gal

B) Truck repairs (1973)	Truck #1	Truck #2
Tires and batteries	$________	$________
Grease, oil, filters and antifreeze	$________	$________
Tune-up	$________	$________
Repairs	$________	$________
Overhauls	$________	$________
Own hours repairing	________ hrs.	________ hrs.

C) Truck housing (1973)	
Present value of building	$________
Portion (%) of building used to house trucks	________ %
Repairs to building	$________

D) Other truck costs (1973)	Truck #1	Truck #2
License	$________	$________
Insurance	$________	$________
Other costs, specify		
________________	$________	$________
________________	$________	$________

5. Under present conditions do you need a new, better, or larger truck? Why? ______________________________
____
____

6. If your one-way grain delivery distance were to increase by 8 to 10 miles in one direction, would you utilize your current truck, require a newer or larger truck, or hire a custom grain hauler? ______________________________
____

7. Do you have further comments on grain transportation? ______
____
____
____