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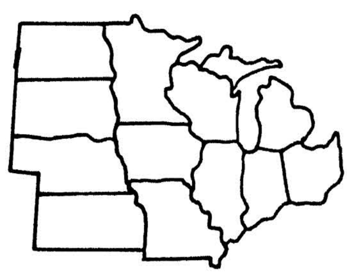
# Estimating Truck Transport Costs for Grain and Fertilizer

WILLIAM F. PAYNE, C. PHILLIP BAUMEL,
AND DAVID E. MOSER



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# Estimating Truck Transport Costs For Grain and Fertilizer*

WILLIAM F. PAYNE, C. PHILLIP BAUMEL,
AND DAVID E. MOSER

## INTRODUCTION

Transportation of grain is a major concern of farmers and country grain elevator managers. The farmer is concerned with moving his grain from the farm to the local grain elevator, while the elevator manager is concerned with transportation of grain to the terminal markets. An increase in transportation costs may cause loss of income to both groups. Currently, the grain transportation system is faced with serious problems, including availability of rail cars, upgrading of rail lines, rail line abandonment, and the availability of custom trucking.

Branch line abandonment and elimination of country elevators might have serious implications for the growth or stability of local communities. In order to assess the effect of branch line abandonment on farmers and grain elevators, the cost of transporting grain by truck in the proposed area of abandonment must be determined. This information will be useful to decision makers who must weigh various alternatives before deciding on the question of branch line abandonment.

The objective of this report is to present results of NC112 studies designed to estimate costs of hauling grain by various sizes and ages of trucks; and by truck/wagon and tractor/wagon combinations.

### Review of Trucking Cost Studies

Two general approaches have been used in previous studies to estimate trucking costs. Kenneth B. Young (13) and Surendra N. Kulshrestha (10) constructed cost equations by statistical estimation from cross-sectional data. After conducting surveys, total costs were separated into various components (depreciation, license cost, fuel cost, etc.) and statistical inference was used. Stephen N. Fuller (7) used the economic-engineering approach to estimate cost equations for assembling grain in Kansas. George St. George and Charles Rust

*One of three reports prepared for publication under the responsibility of the NC112 Publications Subcommittee on Transportation Costs—David E. Moser, Chairman, C. Phillip Baumel and William F. Payne. The other two publications are *Estimating Rail Transport Costs for Grain and Fertilizer*, by Thomas P. Drinka, C. Phillip Baumel, and John J. Miller, and *Estimating Barge Transport Costs for Grain and Fertilizer*, by David E. Moser and Michael W. Woolverton.

(11) completed a study of the cost of hauling grain by semi-trailer truck in Montana, using similar methodology.

Economic-engineering methods were also used to synthesize the costs of model trucking operations in four NC112 contributing projects. Baumel, Drinka, Lifferth, and Miller (2 and 3) developed truck costs by this procedure for use in their analysis of alternative grain transportation systems in Iowa. Payne, *et. al.*, synthesized grain trucking costs in South Dakota. Berglund and Anderson (4), and Salomone, Moser, and Headley (12) used similar methods in developing costs of trucking grain in South-Central Nebraska and Northwest Missouri.

The research procedures employed in the South Dakota study are presented in Part I of this report. The Iowa costing procedure is described in Part II.

# PART I
# THE SOUTH DAKOTA STUDY

Synthetic cost analysis entails building up of the cost function from a study of the trucks' operation. Estimates are based on cost and engineering data from truck manufacturers and dealers, and from sample data where necessary. This procedure was followed in the South Dakota study of trucking costs. In this study, three different truck sizes were believed to be representative of trucks used for hauling grain in South Dakota. In transporting grain from farm to country elevator by truck, a 1½ ton truck, 2 ton truck, and 2½ ton truck were selected as the representative truck sizes. A survey of producers in South Dakota was used to choose representative ages and annual mileage of farm trucks. A random sample of 186 producers throughout the state were interviewed during June, July, and August of 1974.[1] From this survey, 154 farm trucks (not including pickups and recreational vehicles) were identified for study. Table 1 shows the sample stratified by size and age, while Table 2 shows the sample stratified by size and annual mileage. The mean years of manufacture for 1½ ton, 2 ton, and 2½ ton trucks in the sample were 1953, 1963, and 1963 respectively.

In transporting grain from country elevator to the terminal or subterminal market by truck, a 1975 semi-trailer combination with a gross vehicle weight of 23,000 pounds and a payload of 50,000 pounds was selected as representative. Costs were synthesized for these four truck sizes with the result being representative cost equations for hauling grain by truck in South Dakota. The analysis is based upon actual mid-1975 price levels in South Dakota.

## FIXED COSTS

Certain costs of owning a truck remain the same regardless of miles driven. These costs are considered to be fixed. They are estimated on a yearly basis in this study. However, the farm trucks (1½ ton, 2 ton, and 2½ ton) are normally used for purposes other than hauling grain; therefore, the fixed cost of owning the truck was prorated according to the percentage of miles the truck was driven hauling grain.[2] It was assumed that the semi-trailer truck would be used

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[1]An unpublished survey of South Dakota farm trucks conducted during the summer of 1974 by researchers of the Economics Department, South Dakota State University.

[2]There are various methods of allocating the fixed costs of truck ownership. First, all of the fixed cost can be assigned to the predominant use. This method neglects the fact that the farmer receives an economic return from the truck in all uses. Secondly, the fixed cost can be allocated according to the percentage of the farmer's revenue that is generated by grain marketing. This neglects the personal usage of the truck. Lastly, the fixed cost can be allocated according to mileage incurred during different uses. This assumes that there is no difference in wear of the truck among the various uses. (See 9, pp. 80-82).

Table 1

Sample of Farm Trucks in South Dakota Stratified by Size and Age, 1974

| Year | Number of Trucks | Year | Number of Trucks | Year | Number of Trucks |
|---|---|---|---|---|---|
| $1\frac{1}{2}$ ton Trucks | | 2 ton Trucks | | $2\frac{1}{2}$ ton Trucks | |
| 1941 | 1 | 1948 | 1 | 1952 | 1 |
| 1942 | 1 | 1949 | 4 | 1955 | 2 |
| 1944 | 1 | 1950 | 1 | 1957 | 1 |
| 1946 | 2 | 1951 | 3 | 1959 | 1 |
| 1947 | 4 | 1954 | 2 | 1961 | 2 |
| 1948 | 2 | 1955 | 2 | 1963 | 1 |
| 1949 | 2 | 1956 | 1 | 1964 | 2 |
| 1950 | 5 | 1957 | 4 | 1965 | 2 |
| 1951 | 4 | 1958 | 4 | 1967 | 1 |
| 1952 | 1 | 1959 | 7 | 1968 | 2 |
| 1953 | 2 | 1960 | 5 | 1969 | 1 |
| 1955 | 3 | 1961 | 8 | 1974 | 2 |
| 1957 | 1 | 1962 | 4 | | |
| 1958 | 3 | 1963 | 4 | | |
| 1959 | 4 | 1964 | 4 | | |
| 1960 | 2 | 1965 | 4 | $n$ = 18 | |
| 1962 | 1 | 1966 | 5 | $\bar{y}$ = 1963 | |
| 1963 | 1 | 1967 | 2 | | |
| | | 1968 | 6 | | |
| | | 1969 | 3 | | |
| $n$ = 41 | | 1970 | 2 | | |
| $\bar{y}$ = 1953 | | 1971 | 3 | | |
| | | 1972 | 7 | | |
| | | 1973 | 3 | | |
| | | 1974 | 6 | | |
| | | $n$ = 95 | | | |
| | | $\bar{y}$ = 1963 | | | |

Table 2

Sample of Farm Trucks in South Dakota
Stratified by Size and Annual Mileage, 1974

| Annual Mileage | Number of Trucks | Annual Mileage | Number of Trucks | Annual Mileage | Number of Trucks |
|---|---|---|---|---|---|
| 1½ ton Trucks | | 2 ton Trucks | | 2½ ton Trucks | |
| 200 | 1 | 100 | 1 | 1,000 | 1 |
| 250 | 1 | 150 | 1 | 2,000 | 2 |
| 300 | 2 | 200 | 3 | 2,500 | 1 |
| 400 | 1 | 250 | 2 | 3,000 | 2 |
| 500 | 6 | 400 | 1 | 4,000 | 2 |
| 600 | 1 | 500 | 5 | 5,000 | 2 |
| 1,000 | 8 | 1,000 | 4 | 6,000 | 3 |
| 1,200 | 2 | 1,200 | 2 | 7,000 | 1 |
| 1,500 | 1 | 1,500 | 1 | 10,000 | 4 |
| 2,000 | 6 | 1,800 | 1 | | |
| 2,500 | 1 | 2,000 | 13 | | |
| 3,000 | 2 | 2,200 | 1 | n = 18 | |
| 4,000 | 3 | 2,500 | 4 | $\overline{am}$ = 5,361 | |
| 5,000 | 3 | 3,000 | 12 | | |
| 5,500 | 1 | 3,500 | 3 | | |
| 10,000 | 1 | 4,000 | 12 | | |
| 15,000 | 1 | 4,600 | 1 | | |
| | | 5,000 | 4 | | |
| | | 6,000 | 8 | | |
| n = 41 | | 7,000 | 1 | | |
| $\overline{am}$ = 2,310 | | 7,500 | 1 | | |
| | | 8,000 | 5 | | |
| | | 9,000 | 1 | | |
| | | 10,000 | 5 | | |
| | | 13,000 | 1 | | |
| | | 15,000 | 1 | | |
| | | 16,000 | 1 | | |
| | | n = 95 | | | |
| | | $\overline{am}$ = 3,966 | | | |

exclusively for hauling grain and there would be no need to prorate its fixed costs. However, the fixed cost per mile for the semi-trailer truck will decrease with increased annual utilization. To account for this, the annual utilization of the truck was allowed to vary.

Included in the fixed costs were: depreciation, interest on investment, cost of shelter, and license and insurance fees.

### Depreciation for Farm Trucks

A farm truck is capital equipment and as such lasts for many years even though payment for the truck is usually made in the year of purchase. To achieve a more accurate statement of costs, it was necessary to estimate that portion of the value of the truck which was used up in the current year. This charge is termed depreciation.

There are various methods of calculating the depreciation of farm equipment.[3] The problem of choosing the correct method is more complex for farm trucks because many farmers trade in their trucks before the useful life of the truck is over. Two major factors influence the depreciation of a farm truck. The first factor is the wear on the truck due to usage. The straight line method of calculating depreciation estimates this portion of depreciation. The other factor influencing depreciation is change in the market value. The annual revaluation method of calculating depreciation most closely approximates this portion of the depreciation. Therefore, for this study, a combination of these two methods was used, by using the formula,

$$\text{Depreciation} = \frac{PV - MV}{y}$$

where PV is the purchase value of the truck, MV is the present market value of the truck, and y is the number of years the truck has been owned. The truck is revalued over the time period that it has been owned and the depreciation is calculated on a straight line basis over that time period. Table 3 shows the depreciation charges for the farm trucks in 1975.

[3]Five methods of calculating depreciation are identified in J. A. Hopkins and E. O. Heady (8, pp. 76-80). They are annual revaluation, straight line, diminishing balance, sum of the year digits, and compound interest. Kenneth B. Young (13, p. 46) used the annual revaluation method. S. Kulshrestha (9, p. 84) used a combination of the straight line method and annual revaluation method. The straight line method was used by G. St. George and C. Rust (11, p. 5).

Table 3

Depreciation Charges for Various Grain Truck Sizes, 1975

| | 1953 $1\frac{1}{2}$ Ton | 1963 2 Ton | 1963 $2\frac{1}{2}$ Ton |
|---|---|---|---|
| Purchase Price of Truck (including grain box)* | $4,700 | $5,600 | $6,100 |
| Present Market Value of Truck* | $1,000 | $1,900 | $2,000 |
| Number of Years Truck has been Owned | 23 | 13 | 13 |
| Depreciation Charge | $160.87 | $284.62 | $315.38 |

*Purchase price and present market value were obtained from truck and truck equipment dealers in Sioux Falls and Brookings, South Dakota. The trucks were assumed to be equipped with the most common types of grain box and hoist, which were 14 feet, 16 feet, and 18 feet, respectively, for $1\frac{1}{2}$ ton, 2 ton, and $2\frac{1}{2}$ ton trucks.

## Depreciation for Semi-trailer Truck

The depreciation charge for the semi-trailer truck was calculated differently than that for the farm trucks. Ordinarily, semi-trailer trucks are operated for a period of five to eight years and then traded. Change in the market value of these trucks is not a major factor influencing their depreciation. Therefore, the straight line method of calculating depreciation was used. In this method, the formula is:

$$\text{Depreciation} = \frac{PV - SV}{n}$$

where PV is the purchase value of the truck, SV is the salvage value of the truck, and n is the number of years over which the truck is to be depreciated. The truck was depreciated over eight years. Table 4 shows the depreciation charge for the semi-trailer truck in 1975.

Table 4

Depreciation Charge for Semi-Trailer Truck, 1975

| | |
|---|---|
| Purchase Value of Truck | $48,000 |
| Salvage Value of Truck | $ 8,000 |
| Number of Years over which Truck is to be Depreciated | 8 |
| Depreciation Charge | $ 5,000 |

## Interest on Investment for Farm Trucks

An opportunity interest cost was calculated for the market value of the farm trucks. This cost was the foregone alternative of earning a rate of return on the money value of the trucks. It was assumed that the owner would decide once a year if he would continue to use the truck for hauling grain or if he had more attractive opportunities. Therefore, the interest cost was calculated for the present market value of the truck using an interest rate of 6.5 percent. Table 5 shows the interest on investment for the various trucks.

Table 5

Interest on Investment for Various Grain Truck Sizes, 1975

| | 1953 1½ ton | 1963 2 ton | 1963 2½ ton |
|---|---|---|---|
| Present Market Value of Truck | $1,000 | $1,900 | $2,000 |
| Rate of Interest | 6.5% | 6.5% | 6.5% |
| Interest on Investment | $65.00 | $123.50 | $130.00 |

## Interest on Investment for Semi-Trailer Truck

An interest-on-investment cost was calculated for the semi-trailer truck based upon the interest rate charged to borrow that amount of money. However, since the value of the truck decreases with time, the average interest cost was used for the eight-year period the truck was assumed to be owned. Table 6 shows the interest on investment for the semi-trailer truck.

Table 6

Interest on Investment for Semi-Trailer Truck, 1975

| | |
|---|---|
| Average Value of Truck for the 8 Year Period | $24,000 |
| Rate of Interest | 10% |
| Interest on Investment | $ 2,400 |

## Cost of Shelter

Although not all farmers store their trucks in buildings, it was assumed that all farmers incurred a storage cost.[4] If the farmer did not store his truck in a building, it was assumed that this cost would occur in a faster rate of depreciation, or in higher maintenance costs. Therefore, a charge for shelter was included in the fixed costs of owning the trucks.

A rate of $2.50 per square yard was assumed to be the cost of constructing a farm storage building (1, p. 8). Only enough space for the truck was used in calculating the cost of the building, thus negating the need to prorate the cost of the building by the proportion of space used by the truck. The building was depreciated by the straight line method over 20 years. An interest on investment charge was also calculated for the owned value of the building, at the same rates used in calculating previous interest costs. A rate of one percent of the building was used as an estimate of maintenance costs for the building. Table 7 shows the cost of shelter for different sizes of trucks.

## License and Insurance Cost

The final fixed costs of hauling grain by farm truck were license and insurance. It was assumed that all of the trucks would have liability and comprehensive insurance. In addition, the semi-trailer truck would have collision insurance. Table 8 shows the license and insurance costs for the various trucks.

By adding the depreciation charge, interest on investment, cost of shelter, and license and insurance fees, the total fixed cost was obtained. The total fixed cost was prorated according to the percentage of miles the truck was driven hauling grain. Based upon Table 2, two-ton farm trucks are driven an average of 3,966 miles per year. A producer hauling 5,000 bushels of grain a distance of six miles in a 2-ton truck was used for purposes of illustration. A proration rate

[4]Two previous studies that have also included cost of shelter as part of the cost of owning the truck are those of Stephen N. Fuller (6, p. 9) and S. Kulshrestha (9, p. 85).

Table 7

Cost of Shelter for Various Grain Truck Sizes, 1975

| | 1953 $1\frac{1}{2}$ ton | 1963 2 ton | 1963 $2\frac{1}{2}$ ton | Semi-trailer |
|---|---|---|---|---|
| Number of Square Yards | 33 | 33 | 33 | 56 |
| Cost Per Square Yard | $ 2.50 | $ 2.50 | $ 2.50 | $ 2.50 |
| Cost of Building | $82.50 | $82.50 | $82.50 | $140.00 |
| Depreciation | $ 4.13 | $ 4.13 | $ 4.13 | $ 7.00 |
| Interest on Investment | $ 5.36 | $ 5.36 | $ 5.36 | $ 9.10 |
| Maintenance | $ .83 | $ .83 | $ .83 | $ 1.40 |
| Total Cost of Shelter | $10.32 | $10.32 | $10.32 | $ 17.50 |

Table 8

License and Insurance Costs for Various Grain Truck Sizes, 1975

| | 1953 $1\frac{1}{2}$ ton | 1963 2 ton | 1963 $2\frac{1}{2}$ ton | Semi-trailer |
|---|---|---|---|---|
| License Fees* | $34.50 | $40.75 | $47.00 | $1,586.25 |
| Insurance Costs | $36.44 | $36.44 | $36.44 | $3,459.00 |
| Total | $70.94 | $77.19 | $83.44 | $5,045.25 |

*License fees for smaller trucks were obtained from the Brookings County Treasurer's Office. License fees for the semi-trailer truck were provided by the South Dakota Department of Public Safety and consist of a tractor fee, trailer fee, combination fee, registration tax (paid once per truck), plate, and a registration per unit.

of 6 percent was calculated. The proration rate was determined as follows:

$$\frac{5{,}000 \text{ bu. total grain}}{250 \text{ bu. per trip}} \text{ (12 mi. round trip)} = 240 \text{ grain miles}$$

$$\frac{240 \text{ grain miles}}{3966 \text{ total miles}} = .06 \times 100 = 6\% \text{ of total miles hauling grain}$$

The annual mileage for the semi-trailer truck was allowed to vary. The cost equation for the semi-trailer truck was in terms of miles driven per trip, X. In order to calculate this cost, the annual mileage was allowed to vary since as annual mileage increases, average fixed cost per mile decreases.

Table 9 shows the fixed cost of hauling grain by various sizes of trucks in South Dakota for 1975.

Table 9

Fixed Cost of Hauling Grain by Various Size Trucks in South Dakota, 1975 (in dollars)

| | 1953 1½ ton | 1963 2 ton | 1963 2½ ton | Semi-trailer |
|---|---|---|---|---|
| Depreciation | $160.87 | $284.62 | $315.38 | $ 5,000.00 |
| Interest on Investment | 65.00 | 123.50 | 130.00 | 2,400.00 |
| Cost of Shelter | 10.32 | 10.32 | 10.32 | 17.50 |
| License and Insurance Fees | 70.94 | 77.19 | 83.44 | 5,045.25 |
| Total Fixed Cost | 307.13 | 495.63 | 539.14 | 12,462.75 |
| Fixed Cost of Hauling Grain | 18.43 | 29.74 | 32.35 | 12,462.75 |

## VARIABLE COSTS OF HAULING GRAIN

Certain costs associated with operating a truck for hauling grain vary directly with the number of miles the truck is driven in that capacity. Two factors, volume delivered (v) and one-way distance to the elevator (d), determine how many miles the truck is driven hauling grain. These costs are variable, and include: tires, oil and lubrication, fuel, labor, and general maintenance and repair cost. Each cost was considered individually.

### Tire Cost

The three smaller trucks all had six tires that last approximately 50,000 miles. Each tire was estimated to cost $100. Tire cost per mile for these trucks was estimated as:

$$\frac{6 \text{ x } \$100}{50{,}000 \text{ miles}} = .012 \text{ dollars per mile.}$$

For the semi-trailer truck, a total of 18 tires were needed at $159 per tire. Tires were expected to last 100,000 miles. Tire cost per mile for this truck was estimated as:

$$\frac{18 \text{ x } \$159}{100{,}000 \text{ miles}} = .029 \text{ dollars per mile}$$

### Oil and Lubrication Cost

It was estimated that the three smaller trucks would need lubrication and oil every 3,000 miles. The cost of oil was estimated to be $1.00 per quart and six quarts were needed every oil change. It was assumed that the farmer supplied his own labor at an imputed wage rate of $2.25 per hour (9, p. 88). Included in the cost of lubrication were: the cost of grease ($2.00), the cost of an oil filter ($2.80) every other lubrication, and the cost of anti-freeze ($5.00) once a year or every 6,800 miles. It was estimated that each lubrication would require 30 minutes. The oil and lubrication cost for these trucks was estimated to be:

$$\frac{(.5 \text{ x } \$2.25) + (6 \text{ x } \$1.00) + \$2.00}{3{,}000} + \frac{\$2.80}{6{,}000} + \frac{\$5.00}{6{,}800} = .0042 \text{ dollars per mile.}$$

For the semi-trailer truck, it was assumed that the truck would need minor lubrication every 2,000 miles at a cost of $30 and major lubrication every 8,000 miles at a cost of $98. Also, every 14,000 miles a new water filter was needed at a cost of $4.30. The lubrication cost was estimated as:

$$\frac{\$30}{2{,}000} + \frac{\$98}{8{,}000} + \frac{\$4.30}{14{,}000} = .0276 \text{ dollars per mile.}$$

### Fuel Cost

The three smaller trucks used regular gasoline at a price of 51.9 cents per gallon. The estimated mileages per gallon of gasoline were 8 miles per gallon, 7 miles per gallon, and 6 miles per gallon, respectively, for the 1½ ton, 2 ton, and 2½ ton trucks.

The fuel cost for these trucks was estimated to be:

$$\frac{\$.519}{8} = .065 \text{ dollars per mile,}$$

$$\frac{\$.519}{7} = .074 \text{ dollars per mile, and}$$

$$\frac{\$.519}{5} = .087 \text{ dollars per mile, respectively.}$$

The semi-trailer truck used diesel fuel at a cost of 40.9 cents per gallon with an estimated five miles per gallon. The fuel cost for the truck was calculated as

$$\frac{\$.409}{5} = .082 \text{ dollars per mile.}$$

## Labor Cost

Two labor categories were used. First was the cost of labor while driving the truck. An imputed wage rate of $2.25 per hour was used to estimate the cost to the farmer while driving the smaller trucks. The average driving speed was assumed to be 45 miles per hour (40 miles per hour loaded and 50 miles per hour empty). The labor cost per mile was estimated to be:

$$\frac{\$2.25}{45} = .05 \text{ dollars per mile.}$$

The second category of labor cost for the smaller trucks was termed dead-haul labor cost—the labor cost associated with waiting as the truck was loaded, waiting at the elevator to be unloaded, and waiting as the truck was unloaded at the elevator. It was assumed that 15 minutes were required to load the truck, five minutes to unload the truck, and an average of ten minutes waiting to be unloaded.[5] An imputed wage rate of $2.25 per hour was used. Since this cost was incurred on every trip to the elevator (or primary destination), it varied as one-way distance of haul (d) varied. Thus, for the smaller trucks, the dead-haul labor cost was estimated to be:

$$\frac{.5 \text{ hours x } \$2.25 \text{ per hour}}{2d} = \frac{\$.563}{d}$$

where 0.5 hours is equal to 15 minutes plus five minutes plus 10 minutes.

Driver wages for the semi-trailer truck were estimated as 0.13 dollars per mile (5, p. 4; 11, p. 7). Elevators that presently ship grain by rail already have to load the cars. Therefore, it was assumed that the labor cost of loading the semi-trailer was not assigned to the cost of hauling grain, but to operating cost of the elevator. The unloading of the grain was assumed to be handled by the terminal market.

## General Maintenance and Repair

The cost of general maintenance and repair was estimated to be 56 dollars per 2,000 miles, or $\frac{\$56}{2000} = .02$ dollars per mile.

## Total Variable Cost

By adding tire cost, oil and lubrication cost, fuel cost, labor cost, and general maintenance and repair cost, the total variable cost per mile was obtained. Table 10 shows variable cost per mile for the various sizes of trucks.

[5]This assumption was based on interviews with selected farm truck owners.

Table 10

Variable Cost per Mile for Various Grain Truck Sizes, 1975
(in dollars)

| | 1953<br>$1\frac{1}{2}$ ton | 1963<br>2 ton | 1963<br>$2\frac{1}{2}$ ton | 1975<br>Semi-<br>trailer |
|---|---|---|---|---|
| Tire Cost | $.012 | $.012 | $.012 | $.029 |
| Oil and Lubrication Cost | .0042 | .0042 | .0042 | .0276 |
| Fuel Cost | .065 | .074 | .087 | .082 |
| Labor Cost | .05 | .05 | .05 | .13 |
| Maintenance and Repair Cost | .028 | .028 | .028 | .02 |
| Dead-Haul Labor Cost | $\frac{.563}{d}$ | $\frac{.563}{d}$ | $\frac{.563}{d}$ | --- |
| Total Variable Cost per Mile | $.1592 + \frac{.563}{d}$ | $.1682 + \frac{.563}{d}$ | $.1812 + \frac{.563}{d}$ | .2886 |

## ADMINISTRATIVE COSTS

If the elevators operate trucks they will probably experience additional administrative costs. For this study, it was assumed that the elevator would need one man as Dispatcher-Agent-Manager and a part time secretary. Annual administrative costs were estimated as: Salaries—$11,645, Secretarial—$1,100, and Overhead—$2,355, for total administrative costs of $15,100 (reference 11, p. 5). These were typical administrative costs for a five-truck operation, or administrative costs of $3,020 per truck. If the elevator has excess management capacity, or can operate more efficiently, it will be able to decrease this cost.

## COST EQUATIONS

### Total Cost

By adding the fixed cost, variable cost, and administrative cost (for the semi-trailer truck), the total cost of hauling grain was obtained. This cost was in terms of miles driven. However, the number of miles the truck is driven hauling grain depends upon the volume delivered (V), one-way distance of haul (d), and capacity of the truck.

The average load in bushels for the 1½ ton, 2 ton, and 2½ ton trucks was assumed to be 200, 250, and 300 bushels respectively. It was assumed that the semi-trailer truck was always loaded to capacity of 50,000 pounds.

Then, $X = \frac{V}{AL}(2d)$ where X is the annual number of miles the farm truck is driven hauling grain, AL is the average load in bushels, V is the annual total volume delivered in bushels, and d is the one-way distance of haul. Table 11 shows the cost equations for the various farm trucks.

Table 11

Total Cost per Year of Hauling Grain by Various Farm Truck Sizes and Ages, 1975
(in dollars)

| | Equation in Terms of Miles (X) | Equation in Terms of Volume Delivered (V) |
|---|---|---|
| 1953 1½ ton | $TC = 18.43 + .1592X + \frac{.563X}{d}$ | $TC = 18.43 + (.0056 + .0016d)V$ |
| 1963 2 ton | $TC = 29.74 + .1682X + \frac{.563X}{d}$ | $TC = 29.74 + (.0045 + .0013d)V$ |
| 1963 2½ ton | $TC = 32.35 + .1812X + \frac{.563X}{d}$ | $TC = 32.35 + (.0038 + .0012d)V$ |

The total cost of hauling grain resulting from various combinations of annual volume, one-way distance of haul and age is shown in Table 12 for 1½ ton, 2 ton, and 2½ ton trucks.

Annual total cost of hauling grain with a semi-trailer is:

$$TC = \left[ \frac{\text{total fixed cost per year}}{\text{annual mileage}} + \text{variable cost per mile} \right] \text{annual mileage}$$

$$= \left[ \frac{\$15{,}482.75}{\text{annual mileage}} + .2886 \right] \text{annual mileage}$$

The total cost per trip hauling grain with a semi-trailer is directly related to round-trip mileage and inversely related to annual mileage. The latter relationship is the result of allocating fixed costs over a greater number of miles. Total cost per trip for the 1975 semi-trailer is:

$$TC = \left[ \frac{\text{total fixed cost per year}}{\text{annual mileage}} + \text{variable cost per mile} \right] \text{round trip mileage}$$

$$= \left[ \frac{\$15{,}482.75}{\text{annual mileage}} + .2886 \right] \text{round trip mileage}$$

Table 13 shows the estimated total cost per trip for various combinations of annual and round trip mileage for a semi-trailer.

## Average Cost

As grain hauling miles increase, the average cost per mile and average cost per bushel-mile decrease because dead-haul labor cost and fixed costs are prorated over a greater number of miles. Based upon the example of a 1963, two-ton truck, the average cost per mile is:

$$\frac{\text{annual fixed cost of hauling grain}}{\text{annual grain hauling miles}} = \text{variable cost per mile} + \frac{\text{dead haul labor cost}}{2\ (\text{one-way distance to elevator})}$$

$$\frac{29.74}{X} + .1682 + \frac{.563}{d}$$

The equation for average cost per bushel-mile is:

$$\frac{\text{annual fixed cost of hauling grain}}{\text{annual bushels of grain hauled times annual grain hauling miles}} + \frac{\text{dead-haul labor cost}}{\text{average volume loaded in truck} \times 2\ (\text{one-way distance to elevator})} +$$

$$\frac{2\ (\text{variable cost per mile})}{\text{average volume loaded in truck}}$$

$$\frac{29.74}{V \bullet X} + \frac{1.125}{250 \bullet 2d} + \frac{.3364}{250}$$

Table 12

Estimated Total Cost of Hauling Grain by Various Size Trucks as a Function of Volume Delivered and Distance of Haul, 1975 (in dollars)

| Volume Delivered | One-Way Distance of Haul 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1953 1½ ton truck | | | | | |
| 1,000 | 27.23 | 30.43 | 33.63 | 36.83 | 40.03 | 43.23 | 46.43 | 49.63 | 52.83 | 56.03 |
| 2,000 | 36.03 | 42.43 | 48.83 | 55.23 | 61.63 | 68.03 | 74.43 | 80.83 | 87.23 | 93.63 |
| 3,000 | 44.83 | 54.43 | 64.03 | 73.63 | 83.23 | 92.83 | 102.43 | 112.03 | 121.63 | 131.23 |
| 4,000 | 53.63 | 66.43 | 79.23 | 92.03 | 104.83 | 117.63 | 130.43 | 143.23 | 156.03 | 168.83 |
| 5,000 | 62.43 | 78.43 | 94.43 | 110.43 | 126.43 | 142.43 | 158.43 | 174.43 | 190.43 | 206.43 |
| 6,000 | 71.23 | 90.43 | 109.63 | 128.83 | 148.03 | 167.23 | 186.43 | 205.63 | 224.83 | 244.03 |
| 7,000 | 80.03 | 102.43 | 124.83 | 147.23 | 169.63 | 192.03 | 214.43 | 236.83 | 259.23 | 281.63 |
| 8,000 | 88.83 | 114.43 | 140.03 | 165.63 | 191.23 | 216.83 | 242.43 | 268.03 | 293.63 | 319.23 |
| 9,000 | 97.63 | 126.43 | 155.23 | 184.03 | 212.83 | 241.63 | 270.43 | 299.03 | 328.03 | 356.83 |
| 10,000 | 106.43 | 138.43 | 170.43 | 202.43 | 234.43 | 266.43 | 298.43 | 330.43 | 362.43 | 394.43 |
| | | | | | 1963 2 ton truck | | | | | |
| 1,000 | 36.84 | 39.44 | 42.02 | 44.64 | 47.24 | 48.84 | 52.44 | 55.04 | 57.64 | 60.24 |
| 2,000 | 43.94 | 48.14 | 54.34 | 59.54 | 64.74 | 69.94 | 75.14 | 80.34 | 85.54 | 90.74 |
| 3,000 | 51.04 | 58.85 | 66.64 | 74.44 | 82.24 | 90.04 | 97.84 | 105.64 | 113.44 | 121.24 |
| 4,000 | 58.14 | 68.54 | 78.94 | 89.34 | 99.74 | 110.14 | 120.54 | 130.94 | 141.34 | 151.74 |
| 5,000 | 65.24 | 78.24 | 91.24 | 104.24 | 117.24 | 130.24 | 143.24 | 156.24 | 169.24 | 182.24 |
| 6,000 | 72.34 | 87.94 | 103.54 | 119.14 | 134.74 | 150.34 | 165.94 | 181.54 | 197.14 | 212.74 |
| 7,000 | 79.44 | 97.64 | 115.84 | 134.84 | 152.24 | 170.44 | 188.64 | 206.84 | 225.04 | 243.24 |
| 8,000 | 86.54 | 107.34 | 128.14 | 148.94 | 169.74 | 190.54 | 211.34 | 232.14 | 252.94 | 273.74 |
| 9,000 | 93.64 | 117.04 | 140.44 | 163.84 | 187.24 | 210.04 | 234.04 | 257.44 | 280.84 | 304.24 |
| 10,000 | 100.74 | 126.74 | 152.74 | 178.74 | 204.74 | 230.74 | 256.74 | 282.74 | 308.74 | 334.74 |

Table 12 continued

| Volume Delivered | One-Way Distance of Haul 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1963 2½ ton truck | | | | | | |
| 1,000 | 38.55 | 40.95 | 43.35 | 45.35 | 48.15 | 50.55 | 52.95 | 55.35 | 57.75 | 60.15 |
| 2,000 | 44.75 | 49.95 | 54.35 | 59.15 | 63.95 | 68.75 | 73.55 | 78.35 | 83.15 | 87.95 |
| 3,000 | 50.95 | 58.15 | 65.35 | 72.55 | 79.75 | 86.95 | 94.15 | 101.35 | 108.55 | 115.75 |
| 4,000 | 57.15 | 66.75 | 76.35 | 85.95 | 95.55 | 105.15 | 114.75 | 124.35 | 133.95 | 143.55 |
| 5,000 | 63.35 | 75.35 | 87.35 | 99.35 | 111.35 | 123.35 | 135.35 | 147.35 | 159.35 | 171.35 |
| 6,000 | 69.55 | 83.95 | 98.35 | 112.75 | 127.15 | 141.55 | 155.95 | 170.35 | 184.75 | 199.15 |
| 7,000 | 75.75 | 92.55 | 109.35 | 126.15 | 142.95 | 159.75 | 176.55 | 193.35 | 210.15 | 226.95 |
| 8,000 | 81.95 | 101.15 | 120.35 | 139.55 | 158.75 | 177.95 | 197.15 | 216.35 | 235.55 | 254.75 |
| 9,000 | 88.15 | 109.75 | 131.35 | 152.95 | 174.55 | 196.15 | 217.75 | 239.35 | 260.95 | 282.55 |
| 10,000 | 94.35 | 118.35 | 142.35 | 166.35 | 190.35 | 214.35 | 238.35 | 262.35 | 286.35 | 310.35 |

Table 13

Estimated Total Cost per Trip for Transporting Grain by Semi-Trailer Truck, 1975 (in dollars)

| Round Trip Mileage | 100 | 200 | 300 | 400 | 500 | 600 |
|---|---|---|---|---|---|---|
| Annual Mileage | | | | | | |
| 60,000 | 54.66 | 109.32 | 163.98 | 218.64 | 273.30 | 327.96 |
| 80,000 | 48.21 | 96.42 | 144.63 | 192.84 | 241.05 | 289.26 |
| 100,000 | 44.34 | 88.68 | 133.02 | 177.36 | 221.70 | 266.04 |
| 120,000 | 41.76 | 83.52 | 125.28 | 167.04 | 208.80 | 250.56 |

For the semi-trailer truck, average cost per mile is:

$$\frac{\text{total fixed cost per year}}{\text{annual mileage}} + \text{variable cost per mile}$$

$$\frac{\$15{,}482.75}{\text{annual mileage}} + \$.2886$$

Table 14 shows average cost per mile for selected annual mileages.

To facilitate comparison with published commercial rates, average cost per hundredweight may be calculated as:

$$\frac{\left[\frac{\text{total fixed costs per year}}{\text{annual mileage}} + \text{variable cost per mile}\right] \text{round trip mileage}}{\text{average load in hundredweights}}$$

$$\frac{\left[\frac{\$15{,}482.75}{\text{annual mileage}} + .2886\right] \text{round trip mileage}}{500}$$

Table 15 shows average cost per hundredweight for various combinations of annual and round trip mileage.

The final semi-trailer cost to be considered is average cost per hundredweight mile, which is:

$$\frac{\frac{\text{total fixed cost per year}}{\text{annual mileage}} + \text{variable cost per mile}}{\text{average load in hundred-weights}}$$

$$\frac{\frac{\$15{,}482.75}{\text{annual mileage}} + \$.2886}{500}$$

Table 16 shows the average cost of hauling a hundredweight of grain one mile for various combinations of annual and round trip mileage.

Table 14

Estimated Average Cost per Mile for Transporting Grain by Semi-Trailer Truck, 1975 (in cents)

| Annual Mileage | Average Cost per Mile |
|---|---|
| 60,000 | 54.66 |
| 70,000 | 50.97 |
| 80,000 | 48.21 |
| 90,000 | 46.06 |
| 100,000 | 44.34 |
| 110,000 | 42.94 |
| 120,000 | 41.76 |

Table 15

Estimated Average Cost per Hundred-Weight for Transporting Grain by Semi-Trailer Truck, 1975 (in cents)

| Round Trip Mileage | 100 | 200 | 300 | 400 | 500 | 600 |
|---|---|---|---|---|---|---|
| Annual Mileage | | | | | | |
| 60,000 | 10.93 | 21.86 | 32.79 | 43.72 | 54.66 | 65.59 |
| 80,000 | 9.64 | 19.28 | 28.92 | 38.56 | 48.21 | 57.85 |
| 100,000 | 8.86 | 17.73 | 26.60 | 35.47 | 44.34 | 53.20 |
| 120,000 | 8.35 | 16.70 | 25.05 | 33.40 | 41.76 | 50.11 |

Table 16

Average Cost per Hundred-Weight Mile for Transporting Grain by Semi-Trailer Truck, 1975 (in cents)

| Annual Mileage | Average Cost Per Hundred-weight mile |
|---|---|
| 60,000 | .10 |
| 70,000 | .10 |
| 80,000 | .09 |
| 90,000 | .09 |
| 100,000 | .08 |
| 110,000 | .08 |
| 120,000 | .08 |

**Marginal Cost**

Because total cost is a function of both volume and distance of haul, two marginal cost concepts can be developed. Marginal cost with respect to distance can be defined as the additional cost due to an infinitesimal increase in distance of haul. Marginal cost with respect to volume can be defined as the additional cost due to an infinitesimal increase in volume.

Marginal cost can be obtained by differentiating the total cost equation with respect to the relevant variable. For instance, the marginal cost per mile for a 1963 two-ton truck is:

$$TC = \$29.74 + \$.1682X + \frac{\$.563X}{d}$$

$$\frac{d(TC)}{d(X)} = \$.1682 + \frac{\$.563}{d}$$

Marginal cost per bushel for a 1963 two-ton truck is:

$$TC = \$29.74 + (\$.0045 + \$.0013d)V$$

$$\frac{d(TC)}{d(V)} = \$.0045 + \$.0013d$$

Marginal cost per mile for the 1975 semi-trailer is equal to the variable cost per mile of $0.2886.

The equations for marginal cost per mile and marginal cost per bushel are based upon one-way distance to the elevator. Thus the results of the marginal cost calculations should be doubled to account for the return trip.

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# PART II - THE IOWA STUDY*

## Estimated Costs of Hauling Grain by Trucks and Wagons and Hauling Fertilizer by Trucks

### METHODOLOGY

The basic model for estimating operating costs of trucks and farm vehicles hauling grain, fertilizer, and other products in Iowa contains three components: (1) variable costs which are associated with trip distance; (2) fixed costs; and (3) transfer costs which are a function of the cost of loading and unloading. The following equation reflects the total cost component:

$$TC_v = FC_v + VC_vM_v + TR_v$$

where for vehicle-type v,

$TC_v$ = total cost per year,
$FC_v$ = fixed cost per year,
$VC_v$ = variable cost per mile,
$M_v$ = total miles per year, and
$TR_v$ = transfer cost per year.

Variable costs include fuel, oil and oil filters, tires, and driver wages. These were converted to a cost per mile as follows:

$$\text{Fuel cost per mile} = \frac{\text{fuel cost per gallon}}{\text{miles per gallon}}$$

$$\text{Oil and oil filter cost per mile} = \frac{\text{oil and filter cost per change}}{\text{miles per oil change}}$$

$$\text{Tire cost per mile} = \frac{\text{(tire cost per tire) x (tires per vehicle)}}{\text{miles per tire}}$$

$$\text{Driver wage per mile} = \frac{\text{wage per hour}}{\text{miles per hour}}$$

Fixed costs include interest and depreciation, license fees, insurance, highway use taxes, management expenses, and maintenance and repairs.

Interest and depreciation are based on annual equivalent cost computed from the following equation:

$$A.E.C._v = P_v \frac{i(1 + i)n_v}{(1 + i)n_v - 1} - S_v \frac{i}{(1 + i)n_v - 1} \quad (1, p. 620)$$

where for vehicle-type v,

*Baumel, C. Phillip, John J. Miller and Thomas P. Drinka. "An Economic Analysis of Upgrading Rail Branch Lines. A Study of 71 Lines in Iowa." U.S. Department of Commerce, National Technical Information Service, Springfield, Virginia, PB-251 978, March 1976.

$A.E.C._v$ = annual equivalent cost,
$P_v$ = purchase price,
$S_v$ = salvage value,
$n_v$ = service life, and
$i$ = interest rate.

Maintenance and repair costs are assumed to be a proportion of the purchase price of the vehicle and are estimated as follows:

$$MRC_v = \alpha_v P_v$$

where for vehicle-type v,

$MRC_v$ = maintenance and repair cost per year,
$\alpha_v$ = annual maintenance and repair percentage of purchase price, and
$P_v$ = purchase price.

Transfer costs are the costs of the driver waiting time to load and unload and are estimated as follows:

$$TR_v = N_v TW$$

where

$TR_v$ = transfer cost per year of vehicle-type v,
$N_v$ = number of trips per year of vehicle-type v,
$T$ = transfer time (including waiting time, loading time, and unloading time) expressed as hours per trip, and
$W$ = driver wage per hour.

The number of trips per year for all movements in vehicles that are not farmer-owned is based on trip distance, speed, transfer time, and the number of working days per year and is estimated as follows:

$$N_v = \frac{H_v}{\frac{D}{S} + T}$$

where

$N_v$ = number of trips per year of vehicle-type v,
$H_v$ = total working hours per year of vehicle-type v,
$D$ = round-trip distance expressed as miles per trip,
$S$ = speed expressed as miles per hour, and
$T$ = transfer time (including waiting time, loading time, and unloading time) expressed as hours per trip.

The number of trips per year for farmer-owned vehicles is based on the estimated average grain production of cash grain farms and on the payload capacity of the vehicles and is estimated as follows:

$$N_v = \frac{G}{PL_v}$$

where

$N_v$ = number of trips per year of vehicle-type v,
$G$ = average number of bushels of grain produced on a cash grain farm per year, and
$PL_v$ = payload in bushels of vehicle-type v.

The average cost per mile for both types of vehicle is computed as follows:

$$CM_v = \frac{TC_v}{M_v}$$

where

$CM_v$ = average cost per mile of vehicle-type v.

And, the average cost per hundredweight-mile is estimated as follows:

$$CHM_v = \frac{TC_v}{M_v PL_v}$$

where for vehicle-type v,

$CHM_v$ = average cost per hundredweight-mile, and

$PL_v$ = payload in hundredweight.

## ESTIMATED COSTS OF HAULING GRAIN

The basic assumptions in this analysis are:

1. The payloads of the tractor-trailer and tandem trucks are 24 and 13.5 tons, respectively. These trucks are owned and operated by nonregulated independent or private operators.
2. The payloads of the farm truck and gooseneck trailer are 300 bushels. These vehicles are assumed to be farmer-owned and operated only for his use.
3. The 300-bushel farm truck is used only to haul grain from farm to elevator or subterminal.
4. The farm tractor is assumed to be used to pull the grain wagons 12 percent of total tractor time.
5. The gooseneck trailer is used only to haul grain from farm to elevator or subterminal. The farmer already owns a ¾-ton pickup truck. Therefore, only the variable costs of the pickup truck are charged to hauling grain.
6. There are 275 working days or 2,200 working hours per year.
7. The transfer time for loading and unloading grain is 45 minutes per round trip.
8. There are no fertilizer backhauls.
9. The assumed average speed for each trip distance and type of vehicle is as follows:

| | Speed in Miles per Hour | | | | |
|---|---|---|---|---|---|
| Round Trip Distance | Tractor Trailer | Tandem | Gooseneck Trailer | Farm Truck | Farm Wagon |
| 50 | 35 | 35 | 35 | 30 | 12 |
| 150 | 40 | 40 | | | |
| 250 | 45 | | | | |
| 350 | 50 | | | | |

10. This analysis is based on actual mid-1974 price levels in Iowa. At that time, diesel fuel and gasoline prices were $0.45 and $0.50 per gallon, respectively. It was assumed that these prices would increase by $0.05 and $0.10 per gallon, respectively. Thus, the prices used in the analysis were $0.50 and $0.60 per gallon for diesel and gasoline, respectively. All other prices remained at the mid-1974 price levels.

## Estimated Costs of Hauling Grain in Tractor-Trailer and Tandem Trucks

### *FIXED COSTS*

*Interest and Depreciation:* Interest and depreciation costs are based on an annual equivalent cost at a 10-percent interest rate and a five-year life expectancy. The tractor-trailer is assumed to have the following options:

Engine - 270 hp diesel
Transmission - 7 speed
Tires - 1000/20"
Trailer - hopper bottom
Radio

The estimated purchase price for the tractor and hopper bottom trailer in mid-1974 was $36,500. The salvage value at the end of five years is estimated to be $13,000.

The tandem truck was assumed to have the following options:

Engine - 195 hp diesel
Transmission - 7 speed
Tires - front - 1100/20"
back - 1000/20"
Radio

The estimated purchase price of the tandem truck at mid-1974 prices was $19,000. The salvage value at the end of five years was estimated to be $6,500.

*License and Taxes:* The tractor-trailer license fee for 36 tons gross weight is $1,260 per year, and the highway use tax is $222 per year. The tandem license fee for 21 tons gross weight is $590 per year, and the highway use tax is $120 per year.

*Insurance:* Insurance costs vary with the level of coverage. In this analysis, the average annual insurance payment for liability and collision was assumed to be $1,300 for the tractor-trailer and $790 for the tandem truck.

*Management Costs:* Total management costs of $400 per year were assumed for each type of truck.

*Maintenance and Repair Costs:* Maintenance and repair costs per year are assumed to be 5 percent of the purchase price of the vehicles. Thus, the annual maintenance and repair costs are $1,825 and $950 per year for the tractor-trailer and tandem truck, respectively.

### *Variable Costs*

*Fuel Costs:* Fuel consumption for the tractor-trailer is four miles per gallon when traveling loaded and five miles per gallon when traveling empty. Fuel consumption for the tandem truck is 5.2 miles per gallon when traveling loaded and 6.2 miles per gallon when traveling empty.

*Oil and Oil Filter Costs:* The estimated cost of one oil and filter change is $8.00 for both size trucks. The oil and filter are changed every 4,000 miles.

*Tire Costs:* Tire cost and life expectancy by tire size as obtained from tire dealers are as follows:

| Size of Tire | Ply | Price | Life |
|---|---|---|---|
| 1100/20" | 12 | $155.00 | 100,000 miles |
| 1100/20" | 12 | $175.00 | 88,000 miles |

The tractor-trailer unit has 18 units of 1000/20" tires. The tandem truck has eight units of 1000/20" on the rear and two units of 1100/20" on the front.

*Driver Wages:* The average truck driver wage in Waterloo-Cedar Rapids area in September 1974 for driving over four-ton trailer-type trucks was $4.64 per hour[2]. This was increased to $5.00 per hour to add in fringe benefits.

*Average Cost per Mile and per Hundredweight-mile:* The estimated costs per mile and hundredweight-mile for the tractor-trailer and the tandem trucks are presented in Table 1.

## Estimated Costs of Hauling Grain in Farmer-Owned Vehicles

Farmers typically haul grain to market in 300-bushel trucks or in various tractor-wagon combinations. Recently, there has been a trend toward the use of gooseneck trailers with grain boxes powered by a ¾-ton pickup truck. Estimates of the cost of hauling grain in these vehicles are presented in this section. These costs are estimated for a cash grain farmer who would purchase the equipment almost exclusively for hauling grain. Use of this equipment for other purposes would result in costs lower than those estimated for this study.

Based on recent trends, the average cash grain farmer will harvest 300 acres of corn and soybeans in 1979. With 1979 corn yields projected to average 110.9 bushels per acre and soybean yields projected to be 42.4 bushels per acre, the typical cash grain farmer would haul 28,046 bushels of grain to market.

### *Farm Truck - 300-Bushel Size*

*Interest and Depreciation:* The 300-bushel farm truck is a typical farm truck equipped with a grain box and hoist. The mid-1974 purchase price was $10,500 with a salvage value of $2,750 at the end of its ten-year life expectancy.

Table 1

Estimated Costs of Hauling Grain in Tractor-Trailer and Tandem Trucks by Trip Distance and Speed in Mid-1974 Cost Levels

| Round Trip Distance | Speed in Miles per Hour | Number of Trips per Year | Total Annual Mileage | Fixed Cost per Year | Variable Cost per Mile | Transfer Cost per Year | Total Cost per Year | Average Cost per Mile | Average Cost per Hundred-weight Mile |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Tractor-Trailer[a] | | | | | |
| 30 | 35 | 1,368 | 41,040 | $12,506 | $0.2839 | $5,130 | $29,286 | $0.714 | $0.00297 |
| 50 | 35 | 1,009 | 50,450 | 12,506 | 0.2839 | 3,784 | 30,611 | 0.607 | 0.00253 |
| 100 | 40 | 676 | 67,600 | 12,506 | 0.2660 | 2,535 | 33,023 | 0.489 | 0.00204 |
| 150 | 40 | 488 | 73,200 | 12,506 | 0.2660 | 1,830 | 33,807 | 0.462 | 0.00192 |
| 200 | 40 | 382 | 76,400 | 12,506 | 0.2660 | 1,433 | 34,261 | 0.448 | 0.00187 |
| 250 | 45 | 348 | 87,000 | 12,506 | 0.2521 | 1,305 | 35,745 | 0.411 | 0.00171 |
| 300 | 45 | 296 | 88,800 | 12,506 | 0.2521 | 1,110 | 36,004 | 0.405 | 0.00169 |
| 350 | 50 | 283 | 99,050 | 12,506 | 0.2410 | 1,061 | 37,439 | 0.378 | 0.00158 |
| 400 | 50 | 251 | 100,400 | 12,506 | 0.2410 | 941 | 37,644 | 0.375 | 0.00156 |
| | | | | Tandem[b] | | | | | |
| 30 | 35 | 1,368 | 41,040 | $6,797 | $0.2490 | $5,130 | $22,145 | $0.540 | $0.00400 |
| 50 | 35 | 1,009 | 50,450 | 6,797 | 0.2490 | 3,784 | 23,141 | 0.459 | 0.00340 |
| 100 | 40 | 676 | 67,600 | 6,797 | 0.2311 | 2,535 | 24,955 | 0.369 | 0.00273 |
| 150 | 40 | 488 | 73,200 | 6,797 | 0.2311 | 1,830 | 25,544 | 0.349 | 0.00259 |
| 200 | 40 | 382 | 76,400 | 6,797 | 0.2311 | 1,432 | 25,886 | 0.339 | 0.00251 |

[a] Trucking cost function: $\alpha$ = $0.03072, $\beta$ = $0.00144

[b] Trucking cost function: $\alpha$ = $0.02710, $\beta$ = $0.00223

*License:* The license fee for 13 tons gross weight is $310 per year.

*Insurance:* An annual insurance payment of $135 per year was assumed.

*Maintenance and Repair Costs:* The maintenance and repair of a farm truck is a function of the purchase price, age, and miles driven. This truck was assumed to be driven relatively few miles for hauling grain. The annual maintenance and repair cost was estimated to be $150 per year.

*Fuel Costs:* The typical farm truck has a gasoline engine. The average fuel consumption of this type of truck is approximately seven miles per gallon. The price of gasoline delivered in bulk to farmers was assumed to be $0.60 per gallon.

*Oil and Oil Filters:* An oil and oil filter change was assumed to cost $8.00 and would be changed every 5,000 miles.

*Tire Costs:* A 300-bushel truck has six tires estimated to cost $110 each. The life expectancy was assumed to be 35,000 miles per tire.

*Driver Wages:* The driver wage for a farm truck was assumed to be $3.00 per hour. Average speed was assumed to be 30 miles per hour.

### *Tractor-Wagon Combinations*

Three different tractor-wagon combinations were assumed in this analysis. These were:

(1) One 300-bushel gravity flow wagon and a 90 hp tractor.
(2) One 450-bushel gravity flow wagon with brakes and a 110-hp tractor.
(3) Two 300-bushel gravity flow wagons with brakes and a 140-hp tractor.

*Interest and Depreciation:* The purchase price of these wagons fully equipped, including sideboards, is as follows:

| Wagon Size | Purchase Price |
|---|---|
| 300-bushel without brakes | $1,856 |
| 300-bushel with brakes | 2,672 |
| 450-bushel with brakes | 3,091 |

The life expectancy of these wagons is 12 years with essentially no salvage value.

No interest or depreciation is charged for the farm tractor since it is available for crop production.

*Wagon Tires:* Under ordinary conditions, farm wagon tires deteriorate with age before wearing out from use. Thus, wagon tires are a fixed cost. Tires are assumed to be replaced at the end of seven years. Tires for the 300-bushel and 450-bushel wagon cost $60 and $115 each, respectively.

*Tractor Tires:* Grain hauling is estimated to represent 12 percent of total tractor use time. However, the tire wear is greater on roads than for field use.

Therefore, it is assumed that 24 percent of the tractor tire wear is a result of grain hauling. Tires are replaced at the end of five years. The estimated cost of tractor tires and the amount charged to haul grain is as follows:

| Size of Tractor | Total Tire Cost | Annual Tire Cost | Annual Tire Cost Charged to Hauling Grain |
|---|---|---|---|
| 90 hp | $ 810 | $162 | $38.88 |
| 110 hp | 840 | 168 | 40.32 |
| 140 hp | 1,040 | 208 | 49.92 |

*Maintenance and Repair Costs:* There is no maintenance and repair cost of wagons during the early years of wagon use. Only minor repairs are needed, even in later years of wagon use, so repairs are ignored in this analysis.

*Fuel Costs:* The cost of diesel fuel in mid-1974 was $0.45 per gallon. This price, delivered in bulk to farmers, was increased to $0.50 per gallon on the basis of expected price or fuel tax increases.

Fuel consumption for the various size tractors is presented below:

| Size of Tractors | Fuel Consumption per Hour at 12 Miles per Hour |
|---|---|
| 90 hp | 4.14 gallons |
| 110 hp | 4.94 gallons |
| 140 hp | 6.15 gallons |

*Oil and Filter Costs:* The oil and oil filter of farm tractors is assumed to be changed every 120 driving hours. The cost of changing the oil and oil filter is $10.00 for the 90- and 110-hp tractor and $10.60 for the 140-hp tractor.

*Driver Wages:* The driver wage for all sizes of tractors is estimated to be $3.00 per hour. Average speed was assumed to be 12 miles per hour.

### *Gooseneck Trailers*

*Interest and Depreciation:* The purchase price in mid-1974 for a 300-bushel capacity gooseneck trailer equipped with a grain box and all modifications and hookup costs for pickup truck was $4,500. The salvage value at the end of 12 years life expectancy is $500.

*License:* The cost of a 12-ton license for a gooseneck trailer is $30 per year.

*Insurance:* It was assumed that additional insurance added to the pickup insurance policy to cover the trailer costs $15 per year.

*Maintenance and Repair Costs:* The annual maintenance and repairs to the trailer were estimated to be $75 per year. The additional maintenance and repairs to the pickup truck from towing the trailer are estimated to be $75.

*Trailer Tire Costs:* Tires on the trailer are assumed to be replaced at the end of five years. The four tires on the trailer cost $105 each.

*Pickup Truck Tire Costs:* Pickup truck tires are assumed to cost $90 each and have a life expectancy of 30,000 miles.

*Fuel Costs:* The round trip fuel consumption for the pickup truck is 8.5 miles per gallon.

*Oil and Oil Filter Costs:* The oil and oil filter are changed every 4,000 miles and cost $8.00 per change.

*Driver Wages:* It is assumed that the driver wage is $3.00 per hour. Average speed was assumed to be 35 miles per hour.

### *Average Cost per Mile and Hundredweight-Mile*

The estimated costs per mile and hundredweight-mile for hauling grain in the farmer-owned vehicles are presented in Table 2.

### *Weighted Cost of Hauling Grain From Farms to Elevators and Subterminals*

Grain moves from farms to elevators and subterminals in various modes of transport. A single cost function for hauling grain from farms to elevators and subterminals was estimated by first computing a weighted average cost of hauling grain in all types of vehicles, including farm trucks, gooseneck trailers, farm wagons, tandem trucks, and tractor-trailer trucks for each five-mile increment up to 40 round trip miles.

The weights for the weighted average cost of hauling grain were based on the proportion of grain hauled from farm to elevator by each type of vehicle. These weights were obtained from the scale tickets of a local cooperative elevator in central Iowa. All the scale tickets were examined for this elevator for the harvest season of October 1 to November 30, 1974, and for the May 1 to June 30, 1974 period. A total of 12,574 scale tickets from the two-month harvest season and 2,606 scale tickets from the second period were examined. The tickets listed the gross, tare and net weights, owner's name and address, and the hauler. The weighmaster for this cooperative assisted the researchers by classifying each scale ticket as to the type of vehicle used and into five-mile increments of distance from the elevator to owner's farm. These results were adjusted to reflect expected substitution of gooseneck trailers for many trucks by 1980. Truck manufacturers indicated they expect one gooseneck trailer in Iowa for every five farm trucks. The analysis of these scale ticket distances and types of vehicles used is presented in Table 3. These percentages were then used to estimate a weighted cost function from the following regression equation:

$$C_b = a + bm$$

where

Table 2

Estimated Costs of Hauling Grain in Farm Trucks, Gooseneck Trailers, One 300-Bushel Wagon, One 450-Bushel Wagon, and Two 300-Bushel Wagons, by Trip Distance and Speed in Mid-1974 Cost Levels

| Round Trip Distance | Speed in Miles per Hour | Number of Trips per Year | Total Annual Mileage | Fixed Cost per Year | Variable Cost per Mile | Transfer Cost per Year | Total Cost per Year | Average Cost per Mile | Average Cost per Hundred-weight Mile |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Farm Truck | | | | | |
| 10 | 30 | 93.5 | 935 | $2,131.31 | $0.2062 | $210.34 | $2,534.40 | $2.711 | $0.0158 |
| 20 | 30 | 93.5 | 1,870 | 2,131.31 | 0.2062 | 210.34 | 2,727.14 | 1.459 | 0.0085 |
| 30 | 30 | 93.5 | 2,805 | 2,131.31 | 0.2062 | 210.34 | 2,919.89 | 1.041 | 0.0061 |
| 40 | 30 | 93.5 | 3,739 | 2,131.31 | 0.2062 | 210.34 | 3,112.63 | 0.832 | 0.0049 |
| | | | | Gooseneck Trailer | | | | | |
| 10 | 35 | 93.5 | 935 | $ 916.04 | $0.1703 | $210.34 | $1,285.60 | $1.375 | $0.0080 |
| 20 | 35 | 93.5 | 1,870 | 916.04 | 0.1703 | 210.34 | 1,444.81 | 0.773 | 0.0045 |
| 30 | 35 | 93.5 | 2,805 | 916.04 | 0.1703 | 210.34 | 1,604.02 | 0.572 | 0.0033 |
| 40 | 35 | 93.5 | 3,739 | 916.04 | 0.1703 | 210.34 | 1,763.23 | 0.472 | 0.0028 |
| | | | | One 300-Bushel Wagon | | | | | |
| 10 | 12 | 93.5 | 935 | $ 345.58 | $0.4294 | $210.34 | $ 957.40 | $1.024 | $0.0060 |
| 20 | 12 | 93.5 | 1,870 | 345.58 | 0.4294 | 210.34 | 1,358.87 | 0.727 | 0.0042 |
| 30 | 12 | 93.5 | 2,805 | 345.58 | 0.4294 | 210.34 | 1,760.34 | 0.628 | 0.0037 |
| 40 | 12 | 93.5 | 3,739 | 345.58 | 0.4294 | 210.34 | 2,161.82 | 0.578 | 0.0034 |
| | | | | One 450-Bushel Wagon | | | | | |
| 10 | 12 | 62.3 | 623 | $ 559.60 | $0.4628 | $140.23 | $ 988.25 | $1.586 | $0.0062 |
| 20 | 12 | 62.3 | 1,246 | 559.60 | 0.4628 | 140.23 | 1,276.68 | 1.024 | 0.0040 |
| 30 | 12 | 62.3 | 1,870 | 559.60 | 0.4628 | 140.23 | 1,565.10 | 0.837 | 0.0033 |
| 40 | 12 | 62.3 | 2,493 | 559.60 | 0.4628 | 140.23 | 1,853.52 | 0.743 | 0.0029 |
| | | | | Two 300-Bushel Wagons | | | | | |
| 10 | 12 | 46.7 | 467 | $ 902.85 | $0.5136 | $105.17 | $1,248.10 | $2.670 | $0.0078 |
| 20 | 12 | 46.7 | 935 | 902.85 | 0.5136 | 105.17 | 1,488.18 | 1.592 | 0.0047 |
| 30 | 12 | 46.7 | 1,402 | 902.85 | 0.5136 | 105.17 | 1,728.26 | 1.232 | 0.0036 |
| 40 | 12 | 46.7 | 1,870 | 902.85 | 0.5136 | 105.17 | 1,968.34 | 1.053 | 0.0031 |

Table 3

Estimated Percent of Grain Hauled from Farms to Elevators and Subterminals by Type of Vehicle and Distance During Harvest and Nonharvest Periods

| Type of Vehicle | % of Grain Received by Miles Hauled 0-5 Miles | 5.1-10 Miles | 10.1-15 Miles | 15.1-20 Miles |
|---|---|---|---|---|
| | Harvest Time[a] | | | |
| 300-bushel wagon | 37.2 | 14.7 | 4.7 | 0.7 |
| 450-bushel wagon | 4.1 | 3.0 | 1.7 | 0.0 |
| Two 300-bushel wagons | 26.5 | 15.5 | 4.3 | 0.9 |
| Gooseneck trailer | 4.6 | 11.1 | 13.2 | 8.1 |
| Single-axle farm truck | 18.1 | 44.5 | 52.9 | 33.2 |
| Tandem-axle truck | 6.0 | 9.2 | 15.8 | 31.6 |
| Tractor-trailer | 3.6 | 1.9 | 7.6 | 25.5 |
| | Nonharvest Time[b] | | | |
| 300-bushel wagon | 25.9 | 7.3 | 1.4 | 0.3 |
| 450-bushel wagon | 8.5 | 0.3 | 0.9 | 0.0 |
| Two 300-bushel wagons | 3.5 | 0.5 | 1.3 | 0.0 |
| Gooseneck trailer | 11.9 | 14.3 | 13.2 | 13.0 |
| Single-axle farm truck | 47.7 | 57.1 | 52.8 | 51.8 |
| Tandem-axle truck | 3.1 | 20.7 | 30.4 | 26.4 |
| Tractor-trailer | 0.0 | 0.0 | 0.0 | 8.6 |

Source: [a]12,574 scale tickets

[b]2,606 scale tickets

$C_b$ = cost per bushel-mile,
a = constant,
b = regression coefficient, and
m = one-way miles.

The constant "a" is the fixed cost per bushel of providing the vehicle, and loading and unloading the grain. The coefficient "b" is the cost of hauling one bushel of grain one mile.

Regression analyses were then run, using the weighted cost per bushel for five-mile increments up to 20 miles distance for both the harvest period and nonharvest period. The resulting cost functions for the two periods were:

Harvest: $C_b = \$0.047285 + \$0.0013334m$

Nonharvest: $C_b = \$0.057886 + \$0.0011132m$

### Weighted Cost of Hauling Grain From Elevators and Subterminals to Market

The distances from elevators and subterminals to market can range up to 200 one-way miles. Typically, the tractor-trailer truck is used more often than the tandem for longer distance hauls. Therefore, in aggregating the costs in Table 1 into a single cost function for trucking to market, it was assumed that 75 percent of the grain was hauled in tractor-trailers and 25 percent in tandem trucks. The resulting cost function is as follows:

$$C_h = \$0.02982 + \$0.001638m$$

where

$C_h$ = cost per hundredweight and

$m$ = one-way miles.

## ESTIMATED COSTS OF HAULING FERTILIZER

The basic assumptions in this analysis are the same as in trucking grain, except the following:

1. Fertilizer trucked from warehouses to retailers or from a retailer located on a rail line to a retailer on an abandoned line is hauled only in tractor-trailer or tandem trucks.
2. There are no backhauls.
3. Using a fixed conveyor to load fertilizer, transfer time is one hour for the tractor-trailer and ¾ hour for the tandem.
4. The equipment requirements for trucking fertilizer are identical to those for trucking grain.

### Estimated Costs of Trucking Fertilizer in Tractor-Trailer and Tandem Trucks

All the costs of trucking fertilizer are the same as those for trucking grain, except transfer time. This results in higher annual transfer costs, fewer trips per year, and higher costs per mile and costs per hundredweight-mile. The estimated costs per mile and costs per hundredweight-mile are presented in Table 4.

Table 4

Estimated Costs of Hauling Fertilizer in Tractor-Trailer and Tandem Trucks by Trip Distance and Speed in Mid-1974 Cost Levels

| Round Trip Distance | Speed in Miles per Hour | Number of Trips per Year | Total Annual Mileage | Fixed Cost per Year | Variable Cost per Mile | Transfer Cost per Year | Total Cost per Year | Average Cost per Mile | Average Cost per Hundred-weight-Mile |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Tractor-Trailer[a] | | | | | |
| 30 | 35 | 1,184 | 35,520 | $12,506.27 | $0.2839 | $5,920 | $28,508.88 | $0.803 | $0.00334 |
| 50 | 35 | 905 | 45,250 | 12,506.27 | 0.2839 | 4,525 | 29,875.80 | 0.660 | 0.00275 |
| 100 | 40 | 628 | 62,800 | 12,506.27 | 0.2660 | 3,140 | 32,351.07 | 0.515 | 0.00215 |
| 150 | 40 | 463 | 69,450 | 12,506.27 | 0.2660 | 2,315 | 33,294.97 | 0.479 | 0.00200 |
| 200 | 40 | 366 | 73,200 | 12,506.27 | 0.2660 | 1,830 | 33,807.47 | 0.462 | 0.00192 |
| 250 | 45 | 335 | 83,750 | 12,506.27 | 0.2521 | 1,675 | 35,295.57 | 0.421 | 0.00176 |
| 300 | 45 | 286 | 85,800 | 12,506.27 | 0.2521 | 1,430 | 35,567.40 | 0.415 | 0.00173 |
| 350 | 50 | 275 | 96,250 | 12,506.27 | 0.2410 | 1,375 | 37,077.52 | 0.385 | 0.00161 |
| 400 | 50 | 244 | 97,600 | 12,506.27 | 0.2410 | 1,220 | 37,247.87 | 0.382 | 0.00159 |
| | | | | Tandem[b] | | | | | |
| 30 | 35 | 1,368 | 41,040 | $ 6,797.49 | $0.2490 | $5,130 | $22,144.69 | $0.540 | $0.00400 |
| 50 | 35 | 1,009 | 50,450 | 6,797.49 | 0.2490 | 3,784 | 23,141.12 | 0.459 | 0.00340 |
| 100 | 40 | 676 | 67,600 | 6,797.49 | 0.2311 | 2,535 | 24,954.84 | 0.369 | 0.00273 |
| 150 | 40 | 488 | 73,200 | 6,797.49 | 0.2311 | 1,830 | 25,544.00 | 0.349 | 0.00259 |
| 200 | 40 | 382 | 76,400 | 6,797.49 | 0.2311 | 1,433 | 25,886.02 | 0.339 | 0.00251 |

[a] Trucking cost function: $\alpha$ = $0.03630, $\beta$ = $0.00144

[b] Trucking cost function: $\alpha$ = $0.02710, $\beta$ = $0.00223

### Weighted Cost of Hauling Fertilizer From Retailers Located on Rail Lines to Retailers Located on Abandoned Rail Lines

It is assumed that the proportion of tandem to tractor-trailer trucks used to haul fertilizer from retailers located on rail lines to retailers located on abandoned rail lines is the same as for hauling grain from elevators to subterminals. Thus, the weighted cost function is based on 75 percent of the fertilizer hauled in tandem trucks and 25 percent in tractor-trailer trucks. The resulting cost function is as follows:

$$C_h = \$0.0294 + \$0.0020$$

where

$C_h$ = cost per hundredweight and
m = one-way miles.

### Weighted-Cost of Hauling Fertilizer From Warehouses to Retailers

It is assumed that the proportion of tractor-trailer to tandem trucks used to haul fertilizer from warehouses to retailers is the same as for hauling grain from elevators and subterminals to market. Therefore, in aggregating the estimated costs in Table 4 into a single cost function for hauling fertilizer from warehouses to retailers, it was assumed that 75 percent of the grain was hauled by tractor-trailers and 25 percent by tandem trucks. The resulting cost function is as follows:

$$C_h = \$0.0340 + \$0.0016m$$

where

$C_h$ = cost per hundredweight and
m = one-way miles.

## REFERENCES

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2. U.S. Department of Labor, Bureau of Labor Statistics, "Area Wage Survey, Waterloo-Cedar Rapids, Iowa Area," March, 1975.