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COST OF
OPERATING TRUCKS
FOR LIVESTOCK TRANSPORTATION

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ABSTRACT

This report uses synthetic cost analysis to develop cost per mile of operating a livestock truck for trips of different constant lengths and for specific mixtures of trip lengths. The effect of four variables--seasonality of livestock movement, constraints on the number of daily trips, level of backhaul, and level of utilization of revenue equipment--on cost per vehicle mile is shown.

Cost per mile decreases as trip length and yearly mileage increase. For longer trips and higher mileages, most of the cost decrease is due to the spreading of fixed cost over a larger number of miles. Costs in this report are based on estimated costs for a model 10-truck firm, developed from information on operations and costs in 1970 obtained from nine livestock trucking firms.

Keywords: Transportation, livestock, trucking cost.

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SUMMARY

Factors such as seasonality of livestock movement, constraints on the number of daily trips, and level of backhauls affect the cost of trucking livestock for round trips of constant length between 50 and 2,500 miles. Varying levels of utilization of revenue equipment affect cost when a combination of different trip lengths is assumed. These and other costs in this report were developed for a model 10-truck firm based on operations and costs for 1970 obtained from nine livestock trucking firms.

For round trips of constant length, cost per mile when livestock movement is nonseasonal ranges from 37.3 cents at 2,500 miles to 59.4 cents at 50 miles. The cost under seasonal conditions is higher--39 cents at 2,500 miles and 73 cents at 50 miles.

In some cases, livestock truckers are limited in the number of trips they can make per day. For shorter trip lengths affected by limits of one or two trips per day, cost per mile is considerably higher at the 50- and 100-mile length one-trip limit and at the 50-mile two-trip limit than when number of daily trips is unlimited.

An analysis of two levels of backhaul--10 percent and 100 percent--was made to measure the effect of the extra time involved when trucks make the return trip with a load of livestock. Backhaul at the 10-percent level has little effect on cost per mile. However, cost at the 100-percent level of backhaul is considerably higher at the shorter trip lengths than when trucks return empty.

A measurement of levels of use of revenue equipment for a specific mix of trip lengths shows that cost per mile ranges from 38.8 cents for a truck driven 150,000 miles annually to 46.8 cents for one driven only 60,000 miles. As in the previous case involving a fixed trip length, cost variability is due primarily to the spreading of fixed cost over the total number of miles.

COST OF OPERATING TRUCKS FOR LIVESTOCK TRANSPORTATION

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INTRODUCTION

For-hire livestock truckers and their customers are concerned that truckers' rates may not cover their costs. If such is the case, it would be reasonable to expect considerable instability in the for-hire livestock trucking industry. This could result in a serious reduction in the number of livestock trucks available on a for-hire basis. Such a reduction in the for-hire fleet with no offsetting reduction in the transportation requirements of the livestock industry could force livestock shippers to operate more of their own trucks.

The purpose of this study is to analyze the cost of trucking livestock in relation to length of trip and degree of utilization of capacity. The information presented will help livestock shippers and truckers to evaluate the adequacy of livestock trucking rates in maintaining the needed for-hire capacity. It should also enable a livestock shipper to reconstruct livestock trucking cost estimates for the particular setting which he operates. A livestock trucker could incorporate his own cost components and time estimates into these procedures and compare the results with his own cost calculations.

SOURCE AND NATURE OF DATA

The cost data in this report were developed from information obtained from nine livestock trucking firms in the Corn Belt, Great Plains, Intermountain, and Pacific Coast areas. Most firms supplied data from their 1970 accounts. The firms varied considerably in size--from one with five trucks to one with over 60 trucks--and in methods and scope of operations. Thus, their records revealed quite diverse operating results. However, the firms did have similar physical inputs in their trucking operations.

The type of revenue equipment used most often by the nine firms was the combination of heavy-duty diesel tractors and aluminum "pot" trailers. Most tractors were equipped with sleeper cabs, useful on trips requiring a two-man driving team. The "pot" trailers had a dropped center section with two to four loading decks, depending on the type of animal to be hauled. The trailers were built of aluminum so they could carry the maximum weight of live animals while remaining within the size and weight limits permitted by most States.

Trucks owned by the nine firms averaged 4.5 to 5 miles per gallon of fuel. For most firms, average truck speeds ranged from 45 to 50 miles per hour. Backhauls ranged from 0 to 25 percent of total trips; most of these were for only part of the return trip. Average annual miles per truck per firm ranged from about 69,000 to 125,000 miles. The larger annual mileages tended to be associated with firms having relatively less seasonality in their business and a larger proportion of longer trips.

Slack periods of livestock movement result in a potential for considerable idle capacity for livestock trucking firms. Most of the nine firms were able to reduce this idle capacity for their own drivers and tractors. Several firms used some of their drivers and tractors to pull refrigerated vans or other specialized trailers during slack periods. Others used drivers in maintenance and repair of equipment. Layoffs were temporary or applied only to part-time drivers. During peak seasons, some firms hired tractors operated by owners to reduce investment in tractors and to reduce labor cost. Most firms paid their drivers only for the actual time they worked, but some paid them on a weekly or monthly basis.

The cost data in this report should not be considered "average" for or representative of all livestock trucking firms. They were developed by the use of a synthetic analysis of physical operations that appears feasible when checked against the records of the nine firms. Assumptions concerning operations were drawn from interviews with the firm managers or other personnel and from information in research publications. Most of the fixed cost inputs were determined by using the nine-firm average cost per truck for these items. Cost of revenue equipment was determined by using the average cost to the nine firms of 1970-71 model tractors and trailers of the type assumed in this report to be used. Variable cost inputs were determined by using the nine-firm average cost per mile for these items.

COST COMPONENTS

There was considerable variation in the way accounts were maintained by the nine trucking firms. Therefore, part of the analysis of the cost data collected was to identify the differences in accounting procedures and to develop comparable cost components. This was necessary to allow use of the data as inputs in the synthetic analysis of trucking cost.

Information obtained from the firms was used primarily in the identification and development of fixed and variable cost components. It was also used in developing depreciation schedules for buildings, shop and office equipment, and revenue equipment (tractors and trailers).

Cost components for firms of different sizes were developed and a preliminary analysis of their costs was made. This analysis indicated little variation in cost per mile for firms of different sizes. Also, an earlier study by Casavant and Nelson of economies of size and livestock trucking firms revealed that only limited economies are achieved as firm size increases from one truck to three trucks, and even lesser economies are achieved from increases

in size beyond that point. 1/

With the above in mind, it was decided to limit the present study to one firm size. The fixed-cost components presented below are for a model firm operating 10 tractors and trailers. A livestock trucking firm of this size would generate revenues of about \$400,000 per year.

Fixed Cost

Fixed-cost items for the model firm are those expenditures made at a relatively constant rate regardless of the utilization of revenue equipment. The fixed cost for the model firm is estimated to be \$75,893 per year, or \$7,589 per truck (table 1).

Salaries and other compensation paid to the manager and other office personnel comprise the most expensive item of fixed cost, totaling an estimated \$30,209 per year.

The model firm is assumed to have an office and shop building, office and shop equipment, and a pickup truck. Interest--assuming these items are financed by borrowed funds--and depreciation on these items are estimated to total \$4,549 per year. This is based on a total investment of \$43,700 and an interest rate or rate of return of 7.5 percent (table 2).

Table 1--Annual fixed cost for a 10-vehicle livestock trucking firm

Item	Total for year	Average per truck
	<u>Dollars</u>	
Office salaries and fringe benefits...	30,209	3,021
Depreciation and interest <u>1/</u>	20,709	2,071
General office expenses.....	10,540	1,054
Licenses <u>2/</u>	10,410	1,041
Taxes.....	3,148	315
Insurance <u>3/</u>	877	88
Total	75,893	7,589

1/Does not include depreciation on revenue equipment.

2/This assumes that license costs would be prorated among the States in which a firm would operate.

3/Does not include insurance on revenue equipment and employees.

1/Kenneth L. Casavant and David C. Nelson, An Economic Analysis of the Cost of Operating Livestock Trucking Firms in North Dakota, Agr. Econ. Rpt. No. 55, N. Dak. State Univ., July 1967.

Table 2--Depreciation and interest costs of nonrevenue equipment and building for a 10-vehicle livestock trucking firm

Item	Investment cost	Years of depreciation	Salvage value	Yearly depreciation	Yearly interest ^{1/}	Depreciation and interest
	<u>Dollars</u>	<u>Years</u>	<u>Percent</u>	<u>Dollars</u>		
Shop and office...	30,000	20	--	1,500	1,125	2,625
Land.....	2,500	--	--	--	188	188
Office equipment	3,800	10	10	342	157	499
Shop equipment.....	3,800	10	10	342	157	499
Pickup truck....	3,600	5	20	576	162	738
Total....	43,700	--	--	2,760	1,789	4,549

-- = not applicable.

^{1/}Assumes that all assets are financed by borrowed funds at an interest rate of 7.5 percent.

Interest on the revenue equipment was also estimated at 7.5 percent and was applied to one-half of the original cost plus one-half of the salvage value to obtain the midlife value of the equipment (table 3).

All other fixed-cost items are estimated at \$24,975 per year. This includes \$10,410 for licenses for revenue equipment and the pickup truck. Taxes would be \$3,148, including Federal-use taxes on revenue equipment and property taxes on buildings and other equipment. Licenses and taxes on revenue equipment are considered fixed-cost items because they are usually paid on a yearly basis. Insurance for everything except revenue equipment and employees would be \$877.

General office expenses would be \$10,540 for items such as standard telephone charges, office supplies, legal fees, audit, advertising, utilities, dues and charities, bad debt, and travel (table 4).

Table 3--Interest for 10 tractors and livestock trailers

Item	Original cost ^{1/}	Salvage value ^{1/}	Interest per year ^{2/}
	<u>Dollars</u>	<u>Percent</u>	<u>Dollars</u>
Tractors.....	214,000	15	9,230
Trailers.....	154,000	20	6,930
Total.....	368,000	--	16,160

-- = not applicable.

^{1/}See p.6.

^{2/}Assumes that all assets are financed by borrowed funds at an interest rate of 7.5 percent.

Table 4--General office expenses for a 10-vehicle livestock trucking firm

Item	Cost per year
	<u>Dollars</u>
Telephones (standard charge).....	240
Office supplies.....	1,500
Advertising.....	700
Audit.....	1,100
Legal fees.....	900
Utilities.....	500
Dues and charities.....	1,200
Bad debt.....	500
Travel.....	2,300
Miscellaneous.....	1,600
Total.....	10,540

Semifixed Cost

In this analysis, the category semifixed cost is used to classify cost items--such as depreciation on revenue equipment and driver compensation--that have some attributes of the fixed-cost category and other attributes of the variable-cost category. In other reports on trucking cost, depreciation on

revenue equipment is considered a fixed-cost item and driver compensation, a variable-cost item. 2/

The nine firms surveyed indicated a considerable variation in the number of years that revenue equipment was depreciated. The depreciation schedules appear to be closely associated with the yearly mileage utilizations. In this study, 10 years is considered the maximum useful life for a tractor and a trailer. The tractor has an estimated lifetime mileage of 550,000 miles; the trailer, 700,000. The assumed salvage values of the tractor and trailer are 15 and 20 percent of original cost, respectively. Original cost for revenue equipment for the 10-truck firm, based on the previously described type of equipment owned by most of the nine sample firms, is an estimated \$21,400 for the tractor and \$15,400 for the trailer.

Based on these figures, annual depreciation for a tractor is \$1,819 for the first 55,000 miles driven each year, plus 3.31 cents for each additional mile. Annual depreciation for a trailer is \$1,232 for the first 70,000 miles driven each year, plus 1.76 cents for each additional mile.

Driver compensation is the single most expensive cost item overall for most livestock trucking firms. Driver compensation formulas varied considerably among the nine firms, but six paid their regular drivers by the number of miles driven or by a share of the revenue. Most firms made an effort to ensure reasonable levels of annual earnings for their regular drivers.

Driver compensation for this report includes a base pay of 10 cents a mile for one driver and 12 cents a mile for a two-man driving team. This is in line with driver costs for the nine firms. A minimum salary of \$6,000 per year is assumed. In addition to this base pay are fringe benefits which include the employer's contribution to Social Security, unemployment compensation insurance, workman's compensation insurance, and health and welfare plans (table 5). No provision is made for paid holidays or paid vacation for drivers.

Direct Variable Cost

All items included in direct variable cost are directly related to the number of miles driven. Insurance on revenue equipment--which includes liability, property damage, and cargo--is considered a direct variable cost. Most of the nine firms interviewed paid their vehicle insurance premiums according to revenue or miles driven.

It is assumed that drivers would be paid a subsistence of one-half cent per mile per driver for trips totaling over 200 miles. In addition, drivers would receive \$8 per layover period. Such layover periods for single drivers on trips requiring more than 10 hours of driving or 15 hours on duty are necessary to meet Federal highway safety requirements. 3/

2/Orval Kerchner, Costs of Transporting Bulk and Packaged Milk by Truck, Mktg. Res. Rpt. No. 791, Econ. Res. Serv., U.S. Dept. Agr., May 1967; and Herbert H. Moede, Over-The-Road Costs of Hauling Bulk Milk, Mktg. Res. Rpt. No. 919, Econ. Res. Serv., U.S. Dept. Agr., Jan. 1971.

3/U.S. Dept. Transportation, Fed. Highway Admin., The Motor Carrier Safety Regulations, pts. 390-397, par. 395., Wash., D.C., July 1971.

Table 5--Driver compensation, livestock trucking

Item	Cost
Base pay (1 driver) <u>1/</u>	10 cents per mile
Base pay (2-man driving team) <u>2/</u>	12 cents per mile
Social Security <u>3/</u>	5.2% of 1st \$7,800
Unemployment compensation insurance <u>3/</u>	2.2% of 1st \$3,600
Workman's compensation insurance <u>3/</u>	3.6% of total salary
Health and welfare plans <u>3/</u>	1.3% of total salary

1/For mileages lower than 60,000 miles per year, \$6,000 per year is assumed to be base pay.

2/For mileages lower than 100,000 miles (or 50,000 miles driven by each man) per year, \$6,000 per year per man is assumed to be base pay.

3/For each driver.

Together all items of direct variable cost--excluding driver layover cost--add 15.06 to 16.06 cents per mile, depending on length of trip. These items include fuel, tires, insurance on revenue equipment, shop wages, shop supplies, parts, grease and oil, long distance telephone service, driver subsistence, and miscellaneous expenses such as washing, bedding, cleanout, and tolls (table 6).

COST PER MILE

Operating cost is developed for two types of trucking operations. The first type specializes in trips of one specific length; the second handles a specific mix of trip lengths.

To develop costs for trips of specific lengths, it was first necessary to determine the time requirements for each trip length. Table 7 shows the author's estimates of time requirements for round trip lengths of 50 to 2,500 miles. 4/ Some activities--such as vehicle checkout, loading and unloading, and waiting time--are not affected by trip length. Layover time depends on trip length and number of drivers. Time spent for driving, load checks, and meal stops depends on trip length.

In this analysis, it is assumed that tractors and trailers are used 6 days per week, 50 weeks per year. For round trips of under 400 miles, an average 12-hour workday is assumed, for a yearly total of 3,600 truck hours. For round trips of over 400 miles, a 24-hour workday is assumed, for 7,200 truck hours. Minor maintenance, such as tire and oil changes, would be done on the idle day each week and major over-hauls, if necessary, would be done during the 2-week idle period each year.

4/A trip of 1,250 miles one way is about the maximum distance a load of animals can travel without rest, water, and feed.

Table 6--Direct variable cost of operating a livestock truck 1/

Item	Cost per mile
	<u>Cents</u>
Fuel 2/.....	5.68
Tires.....	1.55
Insurance 3/.....	2.4
Shop wages.....	2.3
Shop supplies.....	.23
Parts.....	1.2
Grease and oil.....	.2
Telephone (long distance).....	.5
Driver subsistence 4/.....	--
Miscellaneous 5/.....	1.0
Total.....	15.06

1/Driver layover cost not included.

2/Fuel cost based on 58 percent purchased at a firm's garage and 42 percent purchased on the road.

3/Includes cost of loss and damage claims not covered by insurance.

4/Driver subsistence is .5 cent per mile per driver for trips over 200 miles. Not included here because amount varies.

5/No provision is made for third structure taxes, such as axle-mile tax, since they are paid in only a limited number of States.

The total number of truck hours per year is divided by the total time required for each trip length to determine the feasible number of trips; yearly mileages for each category are then derived from this. These mileage figures are used to develop cost when no seasonality in a firm's business is assumed. However, seasonality in livestock shipments does exist, and livestock haulers must have capacity available during peak periods or forego business. Data from the nine firms indicate that approximately 13 percent of their mileage was during one peak month. This figure is 56 percent above the average mileage for all months. 5/ Therefore, truckers having this degree of seasonality in their business would have only about two-thirds as many miles per truck per year as truckers having no seasonality in their business (table 8). In most of the following tables in which no seasonality in business is assumed, the figures are referred to as "nonseasonal." Where seasonality is assumed, the figures are referred to as "seasonal" and reflect the same level of seasonality as the nine firms had in 1970.

5/Livestock marketings on a seasonal basis are not this variable. However, for-hire truckers may be used for the more variable livestock movements.

Table 7--Estimated time required for specific activities for operating a livestock truck for 1-way loaded round trips at various trip lengths 1/

Round trip mileage	Check-out	Loading time	Unloading time	Driving time	Layover	Waiting time	Load check and meals <u>2/</u>	Total activity	Drivers
-----Hours-----									
									Number
50	0.25	0.25	0.25	1.11	0	2.0	0	3.86	1
100	.25	.25	.25	2.22	0	2.0	0	4.97	1
200	.25	.25	.25	4.44	0	2.0	0	7.19	1
300	.25	.25	.25	6.66	0	2.0	0.75	10.16	1
400	.25	.25	.25	8.88	0	2.0	1.00	12.63	1
500	.25	.25	.25	11.11	<u>3/8.0</u>	2.0	1.75	23.61	1
600	.25	.25	.25	13.33	8.0	2.0	1.75	25.83	1
700	.25	.25	.25	15.56	8.0	2.0	1.75	28.06	1
800	.25	.25	.25	17.78	8.0	2.0	3.50	32.03	1
900	.25	.25	.25	20.00	0	2.0	3.50	26.25	<u>4/2</u>
1,000	.25	.25	.25	22.22	0	2.0	4.25	29.22	2
1,500	.25	.25	.25	33.33	0	2.0	7.00	43.08	2
2,000	.25	.25	.25	44.44	0	2.0	9.50	56.69	2
2,500	.25	.25	.25	55.55	0	2.0	12.25	70.55	2

1/Driving time required is based on the average speed for the 9 livestock trucking firms surveyed, which was 44 miles per hour loaded and 46 miles per hour empty. Other time requirements are based on observations and discussions with livestock truckers.

2/Meal stops (45 minutes) were assumed to be every 4 hours on duty. Load checks (15 minutes) are at the same time as meal stops when vehicle is loaded.

3/Layover is necessary to meet Federal Safety Requirements.

4/Two drivers are necessary to stay within Federal Safety Requirements and still keep livestock moving to destination.

Table 8--Feasible number of trips and yearly mileages for a livestock truck at various lengths 1/

Round trip mileage	Nonseasonal		Seasonal	
	Number of trips	Yearly mileage	Number of trips	Yearly mileage
50	933	46,650	598	29,900
100	724	72,400	464	46,400
200	501	100,200	321	64,200
300	354	106,200	227	68,100
400	285	114,000	182	72,800
500	305	152,500	195	97,500
600	279	167,400	179	107,400
700	257	179,900	165	115,500
800	224	179,200	143	114,400
900	274	246,600	173	155,700
1,000	246	246,000	158	158,000
1,500	167	250,500	107	160,500
2,000	127	254,000	82	164,000
2,500	102	255,000	65	162,500

1/Loaded 1 way only.

Yearly mileage increases for each trip-length category up to 900 miles. At 900 miles, the point where two drivers are first used, yearly mileage becomes somewhat stable. In the nonseasonal group, it ranges from 246,000 to 255,000 miles; in the seasonal group, it ranges from 155,700 to 164,000 miles.

In this analysis, it is assumed that drivers would be limited to some maximum number of hours on duty per year. Table 9 shows driver requirements per truck for three mileage ranges.

A set of four cost equations was developed for computing the cost per mile of operating livestock trucks under various conditions (see appendix). They are used as the basis for cost figures shown in tables 10, 12, 15, and 17.

The costs shown in table 10 are for seasonal and nonseasonal conditions of livestock shipment. In both groups, the total cost per mile for the 50-mile round trip category is considerably higher than cost for other categories. This results from spreading the fixed cost over low yearly mileages for the groups, from the limits set by the 10-year maximum depreciation schedule for revenue equipment, and from the \$6,000 minimum yearly compensation for a driver.

Increase in direct variable cost at 300 miles results from driver subsistence, increase at 500 miles is from layover by single drivers, and increase at 900 miles is from adding a second driver.

The figures in table 10 indicate that seasonality in livestock marketing has little impact on semifixed costs for firms handling only long trips. Of the three cost categories, fixed cost is most affected by seasonality.

Table 9--Driver requirements for operating a livestock truck at various trip lengths

Round trip mileage :	Nonseasonal				Seasonal			
	Total truck activity :	Drivers employed : per truck :	Driver time away : from base :	Time on duty per driver :	Total truck activity ^{4/} :	Drivers employed : per truck :	Driver time away : from base :	Time on duty per driver :
Hours :	Number :	Hours :	Number :	Hours :	Number :	Hours :	Number :	Hours :
0-440 :	3,600	1.5	2,400	2,400	2,308	1.0	2,308	2,308
441-880 . . . :	7,200	2.0	3,600	<u>2/2,308-</u> 2,808	4,616	1.3	3,550	<u>2/2,350-</u> 2,769
881-up :	7,200	<u>1/3.0</u>	4,800	<u>3/2,400</u>	4,616	2.0	4,616	<u>3/2,308</u>

^{1/}With 3 drivers, there would be 1-1/2 driving teams per truck.

^{2/}The range of driver time on duty results from subtracting layover time from time away from base. Layover time as a proportion of total time away from base declines as length of trip increases.

^{3/}When a 2-man driving team is used, the time on duty per driver is one-half of driver time away from base.

^{4/}Total truck activity for the seasonal category is approximately two-thirds of that of the nonseasonal category.

Table 10--Cost of operating a livestock truck for various 1-way loaded round trip lengths

Round trip mileage	Nonseasonal						Seasonal					
	Fixed : cost	Driver : cost	Vehicle : depre-	Depre- : ciation	Direct : cost	Semifixed cost : Total	Fixed : cost	Driver : cost	Vehicle : depre-	Depre- : ciation	Direct : cost	Semifixed cost : Total
50	16.3	6.5	21.5	15.1	59.4	25.4	10.2	22.4	15.1	73.0		
100	10.5	5.1	13.8	15.1	44.5	16.4	6.6	14.4	15.1	52.4		
200	7.6	5.1	11.1	15.1	38.8	11.8	5.2	11.1	15.1	43.2		
300	7.1	5.1	11.1	15.6	38.9	11.1	5.1	11.1	15.6	42.9		
400	6.7	5.1	11.1	15.6	38.4	10.4	5.1	11.1	15.6	42.2		
500	5.0	5.1	11.1	17.2	38.3	7.8	5.1	11.1	17.2	41.1		
600	4.5	5.1	11.1	16.9	37.6	7.1	5.1	11.0	16.9	40.1		
700	4.2	5.1	11.0	16.7	37.0	6.6	5.1	11.0	16.7	39.3		
800	4.2	5.1	11.0	16.6	36.9	6.6	5.1	11.0	16.6	39.3		
900	3.1	5.1	13.2	16.1	37.4	4.9	5.1	13.2	16.1	39.2		
1,000	3.1	5.1	13.2	16.1	37.4	4.8	5.1	13.2	16.1	39.1		
1,500	3.0	5.1	13.2	16.1	37.3	4.7	5.1	13.2	16.1	39.0		
2,000	3.0	5.1	13.2	16.1	37.3	4.6	5.1	13.2	16.1	38.9		
2,500	3.0	5.1	13.2	16.1	37.3	4.7	5.1	13.2	16.1	39.0		

l/Sum of individual costs may not equal total costs because of rounding.

The ownership of enough equipment for peak use (seasonal use) causes vehicle depreciation cost to increase approximately 57 percent at 50-mile trip lengths, 29 percent at 100 miles, and 2 percent at 200 miles. There is no increase for trips of 300 miles and over.

The above analysis assumes that the number of trips per year would be limited only by annual time constraints. However, there may be constraints on the number of trips possible per day. For example, delivery of animals to slaughterhouse plants or to auction markets may have to be made before a certain time. This kind of situation may limit the livestock trucker to only one or two trips per day.

The above-mentioned constraints would affect only short trips. Table 11 gives the feasible number of trips and yearly mileages for trip lengths subject to limits of one or two trips per day. The reductions in yearly mileage would greatly increase cost per mile for the shorter trips (table 12).

Table 11--Feasible number of trips and yearly mileages for a livestock truck at various trip lengths with 1- or 2-trips-per-day constraints

Round trip mileage	Nonseasonal		Seasonal	
	Number of trips	Yearly mileage	Number of trips	Yearly mileage
	<u>Constrained by a 1-trip-per-day limit</u>			
50	300	15,000	192	9,600
100	300	30,000	192	19,200
200	300	60,000	192	38,400
300	300	90,000	192	57,600
400 <u>1/</u>	--	--	--	--
500	300	150,000	192	96,000
600 <u>1/</u>	--	--	--	--
	<u>Constrained by a 2-trips-per-day limit</u>			
50	600	30,000	385	19,250
100	600	60,000	385	38,500
200 <u>2/</u>	--	--	--	--

1/No change from table 8 at 400 miles round trip and at 600 miles round trip and above.

2/No change from table 8 at 200 miles round trip and above.

The costs per mile developed so far are for one-way loads only. Backhauls tend to increase the cost per mile, primarily by increasing round trip time requirements. To illustrate the effects of backhauls, analysis of five trip lengths was made. The various time requirements are shown in table 13.

Table 12--Cost of operating a livestock truck at various trip lengths, with 1- or 2-trips-per-day constraints

Round trip mileage	Nonseasonal					Seasonal				
	Fixed cost	Driver cost	Vehicle depreciation	Variable cost	Semifixed cost	Fixed cost	Driver cost	Vehicle depreciation	Variable cost	Semifixed cost
50	50.6	20.3	44.6	15.1	130.6	79.1	31.8	69.6	15.1	195.5
100	25.3	10.2	22.3	15.1	72.8	39.5	15.9	34.8	15.1	105.3
200	12.6	5.4	11.1	15.1	44.2	19.8	7.9	17.4	15.1	60.2
300	8.4	5.1	11.1	15.6	40.2	13.2	5.4	11.6	15.6	45.8
400 ^{2/}	--	--	--	--	--	--	--	--	--	--
500	5.1	5.1	11.1	17.2	38.4	7.9	5.1	11.1	17.2	41.2
600 ^{2/}	--	--	--	--	--	--	--	--	--	--
<u>Cents per mile</u>										
<u>Constrained by a 1-trip-per-day limit</u>										
50	50.6	20.3	44.6	15.1	130.6	79.1	31.8	69.6	15.1	195.5
100	25.3	10.2	22.3	15.1	72.8	39.5	15.9	34.8	15.1	105.3
200	12.6	5.4	11.1	15.1	44.2	19.8	7.9	17.4	15.1	60.2
300	8.4	5.1	11.1	15.6	40.2	13.2	5.4	11.6	15.6	45.8
400 ^{2/}	--	--	--	--	--	--	--	--	--	--
500	5.1	5.1	11.1	17.2	38.4	7.9	5.1	11.1	17.2	41.2
600 ^{2/}	--	--	--	--	--	--	--	--	--	--
<u>Constrained by a 2-trips-per-day limit</u>										
50	25.3	10.2	22.3	15.1	72.8	39.4	15.8	34.7	15.1	105.1
100	12.6	5.4	14.5	15.1	47.5	19.7	7.9	17.4	15.1	60.1
200 ^{3/}	--	--	--	--	--	--	--	--	--	--

^{1/}Sum of individual costs may not equal total cost because of rounding.

^{2/}No change from table 10 at 400 miles round trip and at 600 miles round trip and above.

^{3/}No change from table 10 at 200 miles round trip and above.

Table 13--Estimated time required for specific activities for operating a livestock truck at various trip lengths with backhauls 1/

Round trip mileage	Check-out	Loading time	Unloading time	Driving time <u>2/</u>	Layover	Waiting time	Load check and meals	Total activity	Drivers
-----Hours-----									
-----Number									
50	0.25	0.50	0.50	1.14	0	4.0	0	6.39	1
200 .....	.25	.50	.50	4.54	0	4.0	0	9.79	1
500 .....	.25	.50	.50	11.36	8.0	4.0	2.0	26.61	1
1,000 .....	.25	.50	.50	22.73	0	4.0	4.75	32.73	2
2,500 .....	.25	.50	.50	56.82	0	4.0	13.75	75.82	2

1/See footnotes to table 7 for explanation of activities.

2/Average speed is assumed to be 44 miles per hour.

The feasible number of trips per year and the yearly mileage were developed at two levels of backhaul for the five trip lengths. At the 10-percent level of backhaul, there was little variation from one-way loaded round trips; but at the 100-percent level, yearly mileage was reduced considerably for the shorter trips, and to some extent for the longer trips (table 14).

Table 14--Feasible number of trips and yearly mileages for a livestock truck at 5 trip lengths and 2 levels of backhaul

Backhaul level and round trip mileage	Nonseasonal		Seasonal	
	Number of trips	Yearly mileage	Number of trips	Yearly mileage
10-percent back- haul:				
50	875	43,750	561	28,050
200	483	96,600	310	62,000
500	301	150,500	193	96,500
1,000	243	243,000	156	156,000
2,500	101	252,500	65	162,500
100-percent back- haul:				
50	563	28,150	361	18,050
200	368	73,600	236	47,200
500	271	135,500	174	87,000
1,000	220	220,000	141	141,000
2,500	95	237,500	61	152,500

At the 10-percent level of backhaul, the cost per vehicle mile varied slightly from that in table 10 at the shorter trip lengths, but there was no difference at the 2,500-mile round trip length. At the 100-percent level of backhaul, the cost per mile was considerably higher than the original cost at the shorter trip lengths, and it was slightly higher at 2,500 miles (table 15). In some cases, backhaul increases the cost per vehicle mile, but the cost per loaded mile always decreases.

Cost per vehicle mile shown in tables 10, 12, and 15 is based on the assumption that firms would specialize in making hauls of only one length throughout the year. Thus, equipment utilization depends on both length of trip and seasonality. However, since most livestock trucking firms probably handle a mixture of trip lengths, as did the nine truckers, an analysis of equipment utilization with a given mix of trip lengths was made.

Table 15--Cost of operating a livestock truck at 5 trip lengths and 2 levels of backhaul

Backhaul level and round trip mileage	Nonseasonal					Seasonal				
	Fixed cost	Driver variable cost	Direct variable cost	Semifixed cost	Total cost l/	Fixed cost	Driver variable cost	Direct variable cost	Semifixed cost	Total cost l/
10-percent backhaul:										
50	17.3	7.0	22.9	15.1	62.3	27.1	10.9	23.8	15.1	76.8
200	7.9	5.1	11.1	15.1	39.1	12.2	5.3	11.1	15.1	43.7
500	5.0	5.1	11.1	17.2	38.4	7.9	5.1	11.1	17.2	41.2
1,000	3.1	5.1	13.2	16.1	37.4	4.9	5.1	13.2	16.1	39.2
2,500	3.0	5.1	13.2	16.1	37.3	4.7	5.1	13.2	16.1	39.0
100-percent backhaul:										
50	27.0	10.8	35.6	15.1	88.5	42.0	16.9	37.0	15.1	111.0
200	10.3	5.1	13.6	15.1	44.1	16.1	6.5	14.2	15.1	51.8
500	5.6	5.1	11.1	17.2	39.0	8.7	5.1	11.1	17.2	42.1
1,000	3.4	5.1	13.2	16.1	37.8	5.4	5.1	13.3	16.1	39.8
2,500	3.2	5.1	13.2	16.1	37.5	5.0	5.1	13.2	16.1	39.3

l/Sum of individual costs may not equal total cost because of rounding.

In this analysis, the fixed-cost figures developed for the 10-truck model firm and the same components chosen for the preceding analysis are used to develop semifixed and direct variable cost. Each truck in the fleet is assumed to have the mix of trips shown in table 16.

Table 16--Trip mix used to develop cost of operating a livestock truck at various levels of utilization

Round trip mileage	Percent of trips	Percent of total miles
100	27	3.27
350	18	7.63
750	19	17.28
1,500	29	52.73
2,250	7	19.09

Driver requirements in this analysis are based on the needs of the entire fleet, instead of on those of individual trucks. A driver would drive 52,464 miles and be on duty 1,560 hours per year to earn the \$6,000 base compensation. It is assumed that a driver would be limited to a yearly maximum of 2,400 hours on duty, for 80,700 miles of driving. Therefore, the 10-truck firm would employ 10 drivers when average yearly mileage per truck ranges from 52,464 to 80,700 miles. At these levels of utilization, one truck would be idle when two drivers are working on another truck. As average yearly mileage per truck increases above 80,700 miles, more drivers would be added. The number of drivers per truck under the above conditions would be as follows:

<u>Annual miles per truck</u>	<u>Drivers per truck</u>
60,000	1.0
75,000	1.0
90,000	1.2
105,000	1.4
120,000	1.5
135,000	1.7
150,000	1.9

The cost equations in the appendix were applied to these seven levels of utilization. Direct variable cost per mile is constant over the entire range of utilization (table 17). Semifixed cost per mile changes slightly from 60,000 to 75,000 miles per year and does not vary for higher levels of utilization. However, fixed cost per mile decreases substantially as mileage rises from 60,000 to 150,000 miles per year.

Table 17--Cost of operating a livestock truck at a mixture of trip lengths and different annual mileages

Annual miles per truck	Fixed cost	Semifixed cost			Direct variable cost	Total cost
		Vehicle depreciation	Driver			
<u>Cents per mile</u>						
60,000	12.6	5.4	12.7	16.1	46.8	
75,000	10.1	5.1	12.6	16.1	43.9	
90,000	8.4	5.1	12.6	16.1	42.2	
105,000	7.2	5.1	12.6	16.1	41.0	
120,000	6.3	5.1	12.6	16.1	40.1	
135,000	5.6	5.1	12.6	16.1	39.4	
150,000	5.1	5.1	12.6	16.1	38.8	

APPENDIX

The cost figures in tables 10, 12, 15, and 17 were developed through the use of four cost equations. In all cases, the equations result in annual cost; this is divided by total annual mileage to obtain the costs per mile shown in the tables. These equations can be used to develop costs for mileages not shown in the tables or they can be modified to show different cost inputs and operational characteristics. The four cost equations are:

1. Fixed cost per truck (excluding minimum vehicle depreciation and minimum driver cost) = \$7,589 (see table 1).
2. Annual vehicle depreciation cost per truck = $\$3,051 + X_1 M_1 + X_2 M_2$

where:

X_1 = Depreciation per mile for tractors--\$0.0331 (see p. 6).

M_2 = Annual mileage in excess of 55,000 miles (see p. 6).

X_2 = Depreciation per mile for trailers--\$0.0176 (see p. 6).

M_2 = Annual mileage in excess of 70,000 miles (see p. 6).

3. Annual driver cost per truck = $N(\$6,685) + X_3 M_3 - X_4 M_4$

where:

N = Number of drivers employed per truck (see table 9 and p. 18).

\$6,685 = Minimum annual cost per driver (see table 5).

X_3 = Driver cost per mile = Base driver cost per mile (10 cents for one driver and 12 cents for two drivers per trip (see table 7)) plus 10.1 percent of this for fringe benefits. (The 2.2 percent for unemployment compensation insurance is not included since its maximum would be paid at \$3,600 per year.)

M_3 = Annual mileage per truck above the amount needed to cover minimum annual cost of one or more drivers (see table 5).

X_4 = 5.2 percent of base driver cost per mile paid by employer for Social Security.

M_4 = Annual mileage per truck above the amount needed to cover maximum income of one or more drivers on which Social Security is paid (\$7,800 per year). The X_4M_4 component is subtracted because the 5.2 percent Social Security payment is included in the 10.1 percent fringe benefits added to base driver cost per mile.

4. Annual direct variable cost per truck = YM

where:

Y = Direct variable cost per mile (see table 6).

M = Annual miles for the truck.

The coefficient Y is 15.06 cents per mile for round trips of up to 200 miles; 15.56 cents for trips of 201 to 440 miles; 15.56 cents plus (\$8 per trip divided by total trip mileage) for trips of 441 to 880 miles; and 16.06 cents for trips of 881 miles or more.

To apply equations 3 and 4 to the analysis of cost where there is a mix of trip lengths, the following information is helpful:

X_5 = Base driver cost per mile =

$$\frac{\$0.10(M_i) + \$0.12(M_{ii})}{100}$$

where:

M_i = Percent of yearly mileage with one driver per trip.

M_{ii} = Percent of yearly mileage with two drivers per trip.

Miles needed for minimum driver cost = $\frac{N(\$6,000)}{X_5}$

Miles needed for maximum Social Security payment = $\frac{N(\$7,800)}{X_5}$

$$Y = \frac{\$0.1506(M_{iii}) + \$0.1556(M_{iv}) + \$0.1606(M_v) + Y_1(M_{vi})}{100}$$

where:

M_{iii} = Percent of yearly mileage where trip length is 0 to 200 miles.

M_{iv} = Percent of yearly mileage where trip length is 221 to 880 miles.

M_v = Percent of yearly mileage where trip length is 881 miles or more.

M_{Vi} = Percent of yearly mileage where trip length is 441 to 880 miles.

Y_1 = Cost per mile for layover = \$8 per trip divided by total trip mileage in the 441 to 880 mile range.



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