Line-Haul Trucking Costs Upgraded, 1964

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The line-haul trucking costs in relation to vehicle gross weights, reported in Highway Research Board Bulletin 301, were developed from 1955 and 1956 cost data obtained by interviews with line-haul highway freight carriers.

In the present paper, these costs are upgraded to 1964 by three types of indexes, the methods of developing this information are described, and the resulting upgraded unit mileage cost data are given in a series of charts.

•IN STUDIES of the economics of prescribed and proposed size and weight limitations for highway freight vehicles and/or trailer combinations, there is a need for data relating operating costs to loaded gross weights. Such information was published in Highway Research Board Bulletin 301, "Line-Haul Trucking Costs in Relation to Vehicle Gross Weights" (1).

The information in this report was based on detailed cost data collected from 611 motor carriers during 1955 and 1956.

This type of cost information becomes dated in our present dynamic economic development, and after several years is not representative, except for overall trends, of operating costs. The present report is a percentage upgrading of the cost data reported in HRB Bulletin 301, and was made in 1964.

It was not difficult to upgrade these costs because in HRB Bulletin 301 the expense elements of motor vehicle operating costs were grouped under six subtitles which are described in the 1952 Interstate Commerce Commission Classification of Accounts (2). The totals of these six groups of accounts may be readily upgraded by using certain data from the Annual ICC "Transport Economics Reports, Part 7 Motor Carriers," (3) and additional data such as line-haul drivers' wage contracts, or other indices.

The line-haul operating costs in Bulletin 301 were grouped into six subtitles, which were assembled into the overall costs. The subtitles are

1. Repair, servicing and lubricant costs;
2. Tire and tube costs;
3. Fuel costs;
4. Driver's wage and subsistence costs;
5. Indirect and overhead costs; and
6. Depreciation and interest costs.

The expense account numbers and descriptions of the several accounts in each group are contained in HRB Bulletin 301, and were not changed in this upgraded supplement.

Reasonably consistent cost data can be obtained for line-haul highway freight vehicle operation, i. e., the costs from the time the line-haul trailer combination leaves one freight terminal until it reaches its terminus freight terminal. This consistency results from fairly uniform rural highway operation, where quite consistent road speeds are attained for terminal-to-terminal operation. In fact, with the increasing development of the Interstate highway system, line-haul highway road speeds will become more uniform.

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The opposite situation exists in urban areas, where operating costs are greatly affected by urban vehicle speeds, stops and starts, and waiting times, all of which influence primarily drivers' costs and fuel costs. For urban operating cost information, a different series of data and indices must be employed to develop urban pickup and delivery operating costs. The data in Bulletin 301 and this upgrading of them do not cover urban delivery costs, but relate only to line-haul operations, primarily of trailer combinations.

To have these cost data in tabular form in smaller increments of loaded gross weight, the equations of the upgraded curves were determined and used to calculate data for several tables of costs with smaller increments of gross weights (tables available from Robley Winfrey, U. S. Bureau of Public Roads).

LOADED GROSS WEIGHT

The term "loaded gross weight" used to designate the weight ratings of trailer combinations by which the operating cost data were distributed has been subject to some misunderstanding, although defined on pages 76 and 77 of Bulletin 301. For clarity, a shortened definition of loaded gross weight is given here.

Loaded gross weight is the tare weight of a vehicle or a trailer combination plus the most usually carried or typical payload when the vehicle or trailer combination is dispatched on a loaded trip. This term is used because the cost data were overall operating data obtained from motor carriers endeavoring to obtain optimum payloads for their typical freight under the operating and delivery conditions required by the class of freight. Further, only two groups of costs for a given vehicle or combination are significantly affected by the different operating services of full payloads in one direction and empty returns, as compared with payloads in both directions; these groups are fuel and tire costs, which are affected by gross weight. The other cost groups are affected predominantly only by time or miles of operation.

UPGRADING INDICES

Many data are available concerning the overall average cost of transporting freight in various sizes and capacities of highway freight vehicles on a nation-wide basis. Such data are contained in the annual reports of certificated motor carriers to the Interstate Commerce Commission (ICC), and to certain state transportation regulatory commissions. These data generally do not contain specific information regarding variations in type and capacity of the freight-transporting equipment, usual cargo weights, loaded gross weights, or amount of regular road travel without cargo. The exceptions to this generalized statement are the cost studies undertaken by the Truck Transport Division of the California Public Utilities Commission in connection with motor carrier tariff revisions for intrastate hauling of various commodities in California. However, these data are not published for general use, but are used in California state hearings.

Such data are of little value to highway engineers who wish to investigate the overall economic advantages which might result from permitting higher axle and gross weights for motor freight trailer combinations and to evaluate these advantages against the increased costs of providing highway facilities with greater load-carrying capacities.

A study of six groupings of the cost elements involved in owning and operating trailer combinations in line-haul service, in an increasing order of loaded gross weights, was reported for 1956 in HRB Bulletin 301. This study developed the increases in operating costs of trailer combinations per vehicle-mile as the loaded gross weights of the trailer combinations increased, and the resulting reductions in payload ton-mile costs. The range of loaded gross weights studied varied from approximately 20,000 to 195,000 lb. This study, which was made by interviewing the motor carriers, included for-hire carriers, private carriers, carriers of light commodities, and carriers of very heavy commodities in weight-limited loads on public highways, as well as private carriers hauling maximum gross loads on private roads.

Since 1956 several of the private toll roads have initiated the use of long double-trailer combinations approximately 100 ft in overall length, with permitted gross weights of approximately 130,000 lb. In addition, 7-axle double-trailer combinations have been developed for use on Michigan public highways for hauling liquid commodities with permitted gross weights of 106,000 lb. Also, 11- and 12-axle trailer combinations are in use on certain Michigan public highways for hauling crushed stone and sheet steel, with permitted gross weights of 148,000 and 161,000 lb. All of these types of very heavy gross weights operations take place on relatively level roads, but the permitted gross weights are approaching the present limits of automotive design, if desired level road speeds with full load are assumed to be not less than 50 mph (as is presently required on the toll roads). Although the range of gross weights considered in HRB Bulletin 301 adequately covers the vehicle gross weight developments since 1956, it is desirable to revise the older cost data to reflect current costs. The methods of upgrading the previous cost data, the indices used, and the resulting cost curves, constitute the balance of the report.

The data are reported under three headings: (a) gasoline and diesel engine powered trailer combinations, (b) gasoline engine powered trailer combinations, and (c) diesel engine powered trailer combinations. However, it is believed that the data for gasoline and diesel engine powered trailer combinations are most representative of the overall average costs of the mixture of types of trailer combinations in use on the highways of the continental United States.

UPGRADING TECHNIQUES

Several indices were investigated as means for upgrading the 1956 cost figures. However, the latter cost elements were assembled on the basis of the expense account definitions prescribed in the ICC's "Uniform System of Accounts for Class I Common and Contract Motor Carriers of Property—Issue of 1952" (2). The various individual expense accounts comprising each of the six groups of costs charted in HRB Bulletin 301 are described in that report.

Each year the Bureau of Transport Economics and Statistics of the ICC issues its "Transport Statistics in the United States" in several parts. In Part 7, which relates to motor carriers (3, 4), the specified ICC expense accounts and statistical information are tabulated and summarized by different groupings of carriers with similar operating characteristics. One group of carriers described as "Class I Common Carriers of General Freight Engaged in Intercity Service Operating With Owned Equipment Principally" has characteristics similar to the carriers reported in HRB Bulletin 301. The expense account and statistical data regarding these carriers are reported in Tables 5, 7, 8 and 14 in Part 7, Motor Carriers, ICC Transport Statistics (3, 4) for each year.

Although the number of carriers in this category has decreased because of mergers and redefinition of class I motor carriers, the number of vehicles and vehicle-miles has remained adequately constant, as is shown in the following schedule.

1. Total number of power units owned in intercity service—31,424 (1956), 28,609 (1962);
2. Total vehicle-miles operated in intercity service owned power unit vehicles—1,609,849,389 (1956), 1,958,930,439 (1962); and
3. Average vehicle-miles per owned power vehicle per annum—51,230 (1956), 68,473 (1962).

Power vehicles are being operated both more extensively and more efficiently, as can be expected of modern automotive equipment. Further indication of the comparative use of these carriers is shown by the following data developed from ICC (Table 14, 3, 4).

1. Average tons of freight hauled annually by line-haul power units (both owned and rented)—1,964 (1956), 2,326 (1962);
2. Average revenue per line-haul power unit (both owned and rented)—$37,683 (1956), $59,163 (1962);
3. Freight revenue per line-haul vehicle-mile (both owned and rented)—$0.735 (1956), $0.861 (1962); and
4. Costs per line-haul vehicle-mile (both owned and rented)—$0.711 (1956), $0.830 (1962).

For the reasons previously mentioned, the relative costs from the ICC Transport Statistics (3, 4) for 1956 and 1962 are used as the primary indices to upgrade the line-haul trucking costs for different loaded gross weights. Further, except for changes in driver wage rates, there were only small changes in the majority of the different cost elements during 1963. For this reason, the upgraded cost data are assumed typical for the first quarter of 1964. However, in January 1964 a new driver wage contract was negotiated, which resulted in a substantial increase in costs. The driver wage and subsistence costs are upgraded to reflect these 1964 wage rates. As a result of these factors, the revised cost data reported in this upgrading study are considered representative of trucking costs as of March 1964.

The revised cost data are presented in curve form on charts similar to the cost curves shown in Figures 18 through 23 of HRB Bulletin 301.

PRESENTATION AND METHODS OF UPGRADING VEHICLE-MILE COST DATA

Grouping by ICC Accounts

The ICC Uniform System of Accounts (2) was used as a guide in identifying and grouping accounts for the purpose of computing the major categories of costs, which represent costs directly related to line-haul operations.

To reflect the overall costs per vehicle-mile of operation, the individual expense accounts have been grouped under six general descriptive headings. Cumulative cost curves have also been developed under these general headings, using methods similar to those in HRB Bulletin 301.

Repair, Servicing, and Lubricant Costs

Repair and servicing costs included the costs of engine oil in the 1956 data. The total amounts spent for each of these two cost items by the selected group of carriers (class I common carriers of general freight engaged in intercity service operating with owned equipment principally) are reported in Table 8 of the 1956 and 1962 ICC Transport Statistics (3, 4). In both ICC reports, the amounts include the costs for line-haul revenue equipment (tractors, tractive trucks and trailers) and city pickup and delivery trucks. However, the expenses of city pickup and delivery trucks, because of fewer miles of travel and less severe daily service, account for only a small portion of the total cost of repair, servicing, and lubricants. Further, these combined costs for carriers' vehicles are the only ones available in published reports.

Table 14 of the 1956 and 1962 ICC Transport Statistics (3, 4) gives the total vehicle-miles of owned line-haul power vehicles, and Table 8 of these reports gives cost data for the same series of carriers. Vehicle-mile data for city pickup and delivery trucks are not reported. Hence, the vehicle-mile data for the line-haul power vehicles are considered as representative of the vehicle mileage for each year.

To develop an upgrading index factor to apply to the 1956 cost data, the total amounts spent by this group of carriers for repairs, servicing, and lubricants in the years 1956 and 1962 were divided by the appropriate line-haul power unit vehicle-miles to give an average cost for these expense items in terms of cents per power unit vehicle-mile for each year. The 1962 cents per vehicle-mile were divided by the 1956 cents per vehicle-mile to develop the upgrading factor of 1.077 by which the 1956 costs in HRB Bulletin 301 are multiplied to develop appropriate cost data for first quarter 1964.

The data given in the table on page 5 are derived from Tables 8 and 14 of the 1956 (3) and 1962 (4) ICC Transport Statistics.

The resulting upgraded cost data for first quarter 1964 are shown in Figures 1, 2, and 3.

Tire and Tube Costs

The tire and tube costs reported in HRB Bulletin 301 are for line-haul revenue vehicles only. The tire and tube costs reported for the same selected ICC Class I common

Item	1956	1962
Repairs and servicing, revenue equipment	$ 100,960,309	$ 133,038,261
Oil for revenue equipment	3,292,275	3,781,929
Total owned line-haul power units	31,424	28,609
Total owned line-haul power unit vehicle-miles	1,609,849,389	1,958,930,439
Repair and servicing per power unit vehicle-mile	0.0627	0.0679
Oil per vehicle-mile	0.0021	0.0019
Average repair and oil costs per vehicle-mile	$ 0.0648	$ 0.0698

$$\frac{\text{1962 unit cost}}{\text{1956 unit cost}} = \frac{0.0698}{0.0648} = 1.077 \text{ upgrading factor}$$

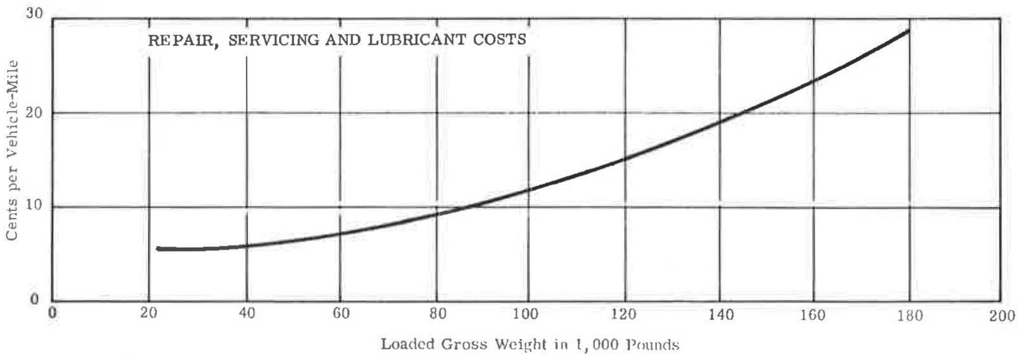

Figure 1. Gasoline and diesel engine powered trailer combinations.

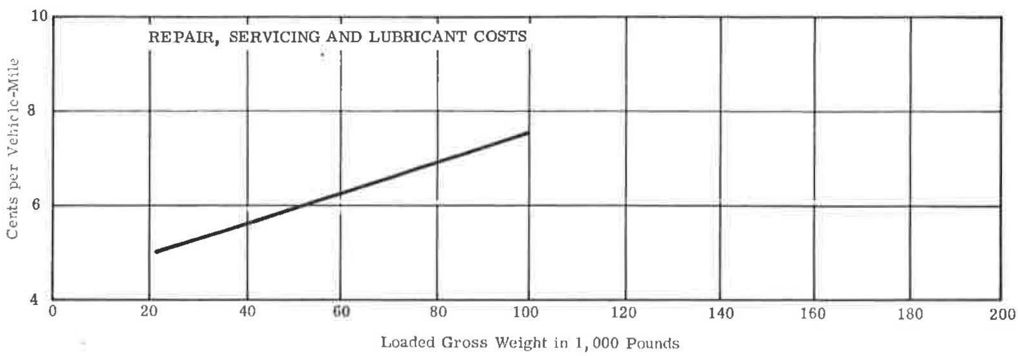

Figure 2. Gasoline engine powered trailer combinations.

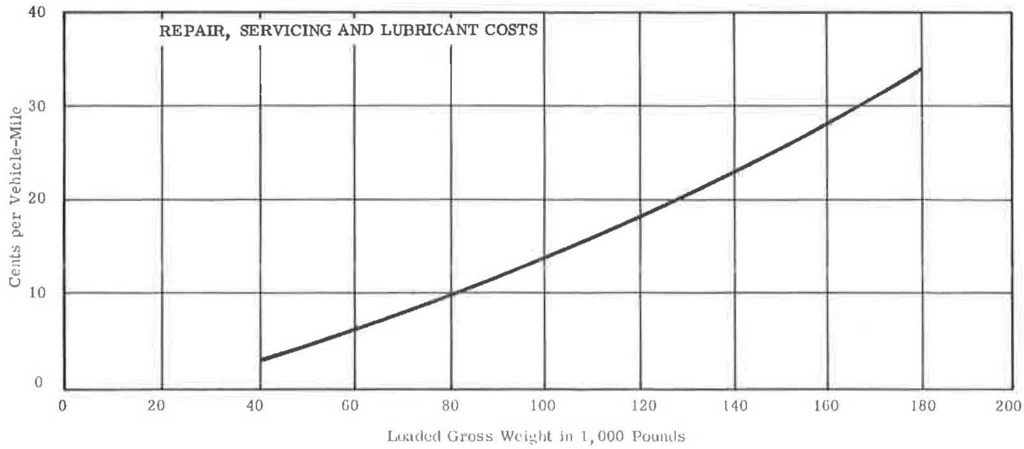

Figure 3. Diesel engine powered trailer combinations.

carriers in Tables 8 and 14 of the 1956 and 1962 ICC Transport Statistics (3, 4) include the costs of tires and tubes for city pickup and delivery as well as the costs of tires and tubes for line-haul revenue equipment. However, because of less annual travel and less severe service, the costs of tires and tubes for city trucks is only a minor part of the reported total tire and tube costs; hence, as these cost totals are published they are used to develop the upgrading index factors to be used with the tire and tube costs reported in HRB Bulletin 301.

The average vehicle-mile costs for tires and tubes for 1956 and 1962 were developed by dividing the total tire and tube costs for each year by the appropriate total owned power unit vehicle-miles. The average vehicle-mile cost for 1962 was divided by the average vehicle-mile cost for 1956 to develop the upgrading factor of 0.894 by which the 1956 costs are multiplied to develop appropriate cost data for first quarter 1964.

The following details of these data are from Tables 8 and 14 of the 1956 and 1962 ICC Transport Statistics.

Item	1956	1962
Tire and tube costs	$ 34,705,212	$ 37,894,275
Total owned vehicle-miles	1,609,849,389	1,958,930,439
Tire and tube costs per vehicle-mile	$ 0.0216	$ 0.0193

$$\frac{\text{1962 unit cost}}{\text{1956 unit cost}} = \frac{0.0193}{0.0216} = 0.894 \text{ upgrading factor}$$

The resulting upgraded cost data for the first quarter 1964 are shown in Figures 4, 5, and 6.

Fuel Costs

The data on fuel costs indicate a considerable reduction in fuel costs per vehicle-mile, undoubtedly as a result of the interaction of two developments in the industry. In line-haul, intercity service there has been a considerable transition from gasoline engines to the use of diesel engines with their better fuel economy. Also, there have been improvements in gasoline fuels and gasoline engines which have resulted in improved fuel economy for gasoline engines.

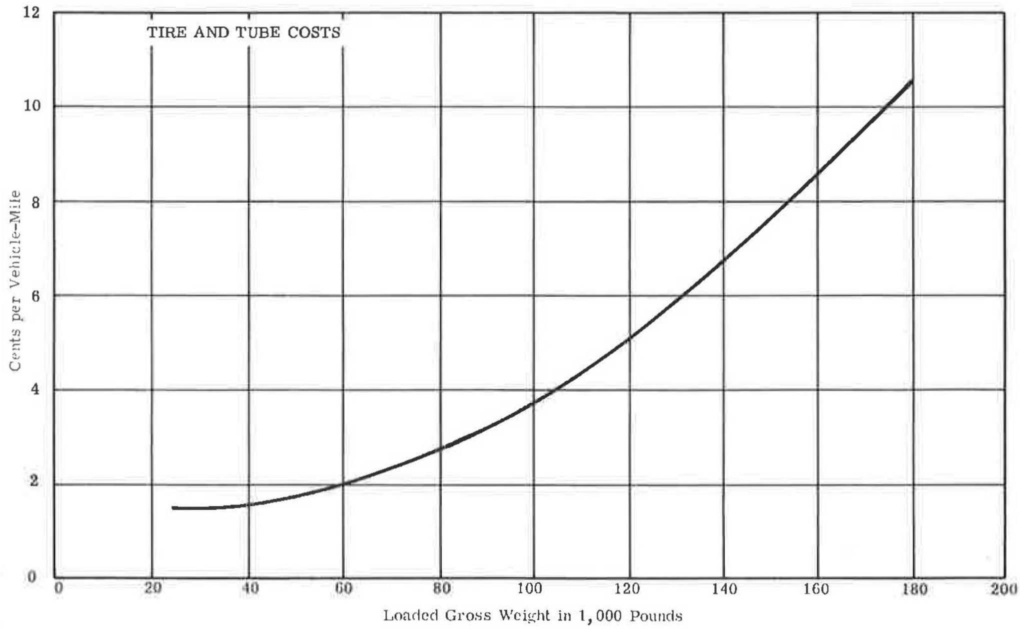

Figure 4. Gasoline and diesel engine powered trailer combinations.

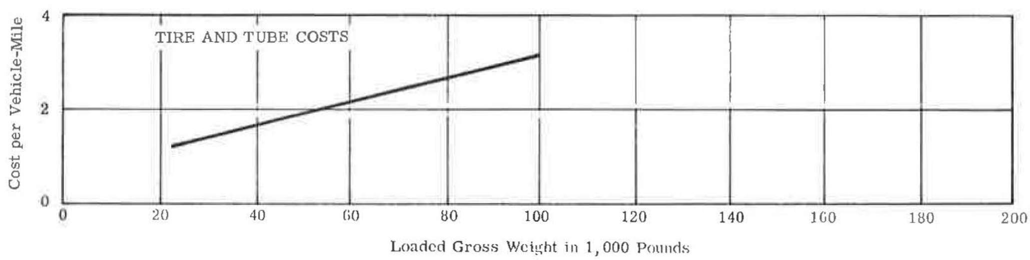

Figure 5. Gasoline engine powered trailer combinations.

For these reasons it is not surprising to obtain the reductions in fuel costs indicated by the changes in these cost items in the ICC Transport Statistics for 1956 (3) and 1962 (4). The total amounts reported under "fuel for revenue equipment" in the two series of ICC Transport Statistics (3, 4) include fuel for city pickup and delivery trucks. As was the case with tire costs, the fuel for city trucks is a small portion of the total fuel consumed. Hence, the average vehicle-mile cost for fuel, developed by dividing the total fuel costs from Table 8 in the 1956 and 1962 ICC Transport Statistics (3, 4) by the line-haul, intercity mileages obtained from Table 14 of the same reports, may be used to develop the upgrading factor for fuel costs. Dividing the average vehicle-mile fuel cost, so developed for 1962 by the similar average vehicle-mile fuel cost for 1956, gives the upgrading factor of 0.765 by which 1956 fuel costs are upgraded to first quarter 1964 costs.

The details of these data and calculations are given in the table on page 8; the original fuel cost data are from Tables 8 and 14 of the 1956 and 1962 ICC Transport Statistics (3, 4).

The resulting upgraded cost data for the first quarter 1964 are shown in Figures 7, 8 and 9. (Fuel costs do not include state and Federal fuel taxes because the latter are payments on the costs of providing highway facilities, and as such are not vehicular cost.)

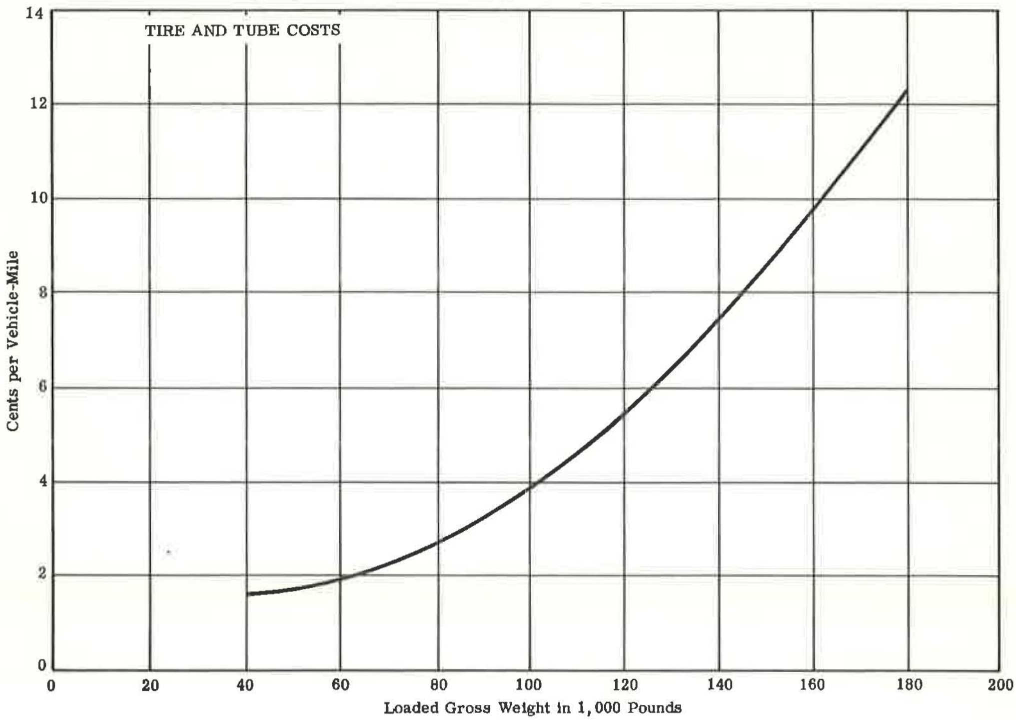

Figure 6. Diesel engine powered trailer combinations.

Item	1956	1962
Fuel for revenue equipment	$ 61,140,346	$ 55,730,201
Total vehicle-miles, intercity	1,712,129,255	2,040,395,692
Average fuel cost per vehicle-mile	$ 0.0357	$ 0.0273

$$\frac{\text{1962 unit cost}}{\text{1956 unit cost}} = \frac{0.0273}{0.0357} = 0.765 \text{ upgrading factor}$$

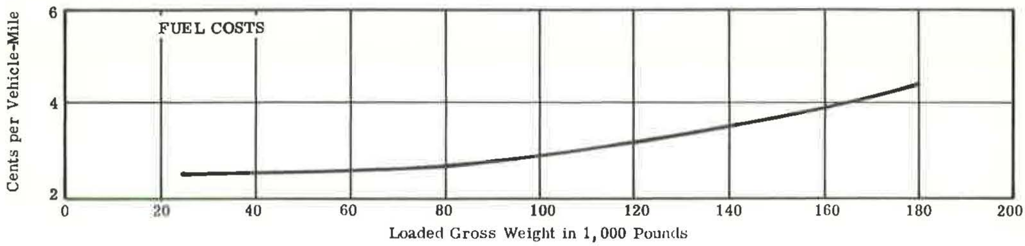

Figure 7. Gasoline and diesel engine powered trailer combinations.

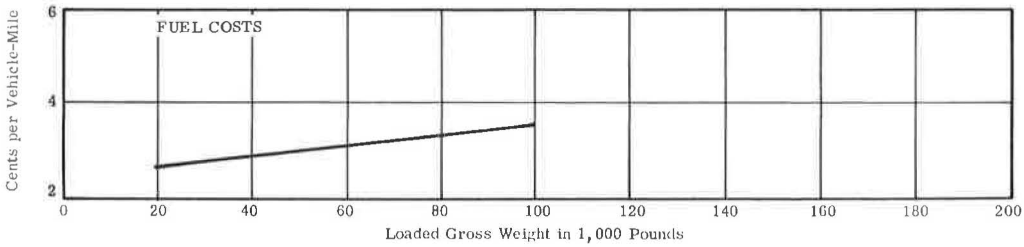

Figure 8. Gasoline engine powered trailer combinations.

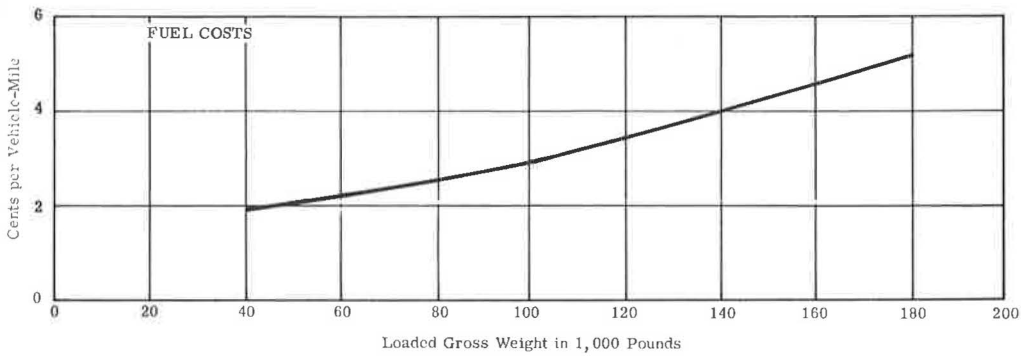

Figure 9. Diesel engine powered trailer combinations.

Driver Wage and Subsistence Costs

The greatest change in trucking costs occurred in driver wage rates. A new wage contract for over-the-road, line-haul drivers was negotiated in January 1964 (5), and the first increase became effective shortly thereafter. This year (1964) in 26 of the western and central states the wage contracts (5) are on a mileage basis, as compared with 23 states in 1956. The 1964 contract rates are given in Table 1.

These new wage rates are plotted in Figure 10, using the same procedure as in the 1956 study (1) to develop wage rates for trailer combinations with a range of loaded gross weights. This procedure recognizes the principle of productivity pay differentials that are indicated by the contract wage scales for the different trailer combinations having the typical loaded gross weights shown in the 1956 study (1).

Although the subsistence costs for away-from-home layovers were increased slightly in the new contracts, the apparently greater average annual miles per power vehicle probably offsets this subsistence allowance increase to such an extent that vehicle-mile costs for subsistence are not substantially changed from the estimates in the 1956 study.

The 1964 driver wage rates for different power unit vehicle-miles are plotted in Figure 10, using the same typical loaded gross weights of the specified trailer combinations as shown in Figure 10 of the 1956 study. The 1962 wage rates at the 20,000-, 40,000-, 60,000-lb, etc., ordinates for both the single cargo body combinations and the double cargo body combinations were divided by similar wage rates on the 1956 charts to develop upgrading factors for driver wage and subsistence costs. There

TABLE 1

1964 OVER ROAD DRIVERS' MILEAGE RATES PER VEHICLE-MILE

Vehicle	$/Veh-Mi
3-axle tractor semitrailer	0.1025
4-axle tractor semitrailer	0.1050
5-axle tractor semitrailer	0.10625
Double cargo vehicle combination	0.1165

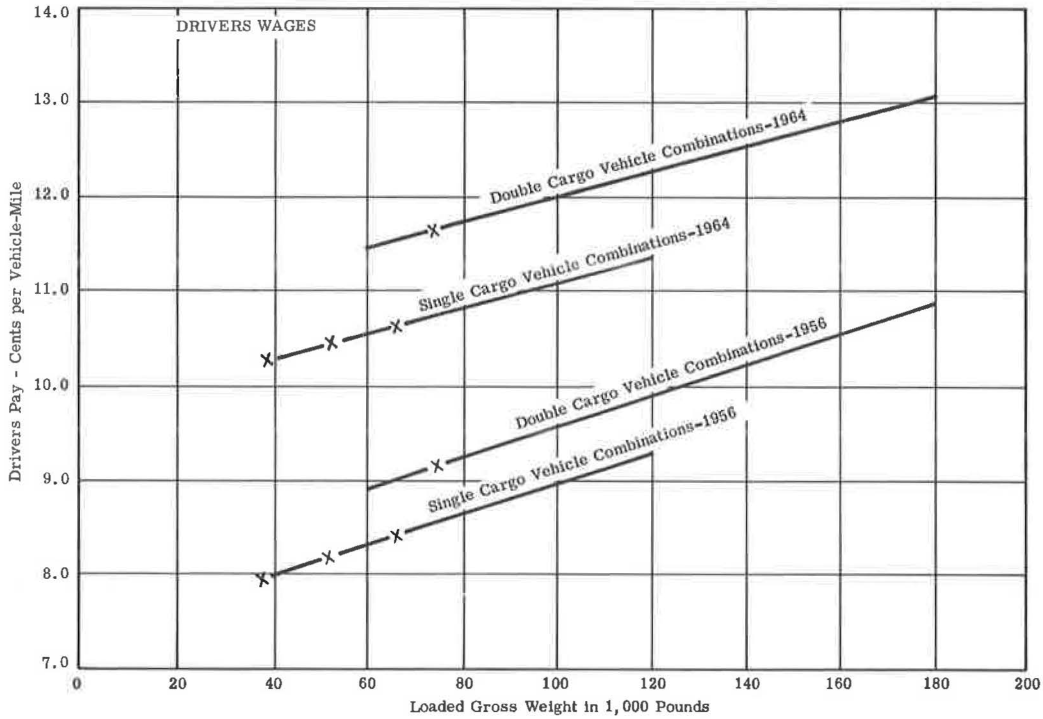

Figure 10. Drivers wage rates per mile by gross weight of trailer combinations.

appears to be a slight trend toward bringing together the mileage wage rates for different trailer combinations, as the increases were slightly smaller, percentage-wise, for the heavier vehicles than for the 2-S1 trailer combination. Hence it was necessary to develop an upgrading factor at each 20,000-lb ordinate on the Driver's Wage Rate Chart (Fig. 10).

Using these several upgrading factors with the vehicle-mile costs at the several 20,000-lb ordinates of the drivers wage and subsistence charts for 1956 (Figs. 21 through 23, HRB Bulletin 301), revised Driver Wage and Subsistence Costs for 1964 were developed as shown in Figures 11, 12, and 13.

Indirect and Overhead Costs

The Indirect and Overhead Costs indicated in Table 2 were tabulated from Tables 8 and 14 of the ICC Transport Statistics for 1956 (3) and 1962 (4). One change made in the 1962 ICC Table 8 is that Employees Welfare Expenses are shown under each department grouping, rather than only in the administration department, as in 1956. However, in Table 2 all related Employee Welfare Expenses are grouped under one heading, as was the case in the 1956 study. Employee Welfare Expenses are more commonly known as Fringe Benefits, and have increased in all industries, either as a matter of contract or management policy.

The calculations in Table 2 indicate an average increase in Indirect and Overhead Costs of $0.0149 per power unit vehicle-mile. Indirect and Overhead Costs are primarily "time" expenses and are not directly related to vehicle weights. Hence, these costs are uniformly increased $0.0149 per vehicle-mile over the entire range of loaded gross weights. The upgraded values for Indirect and Overhead Costs are shown in Figures 14, 15 and 16.

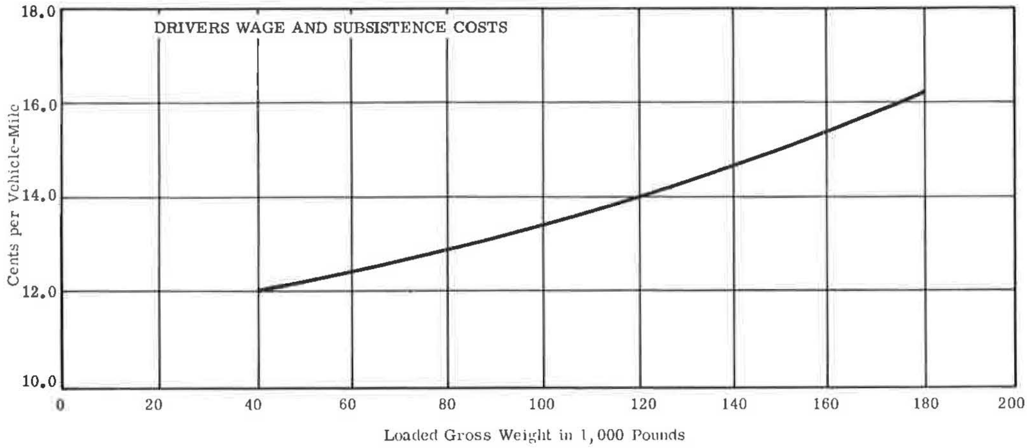

Figure 11. Gasoline and diesel engine powered trailer combinations.

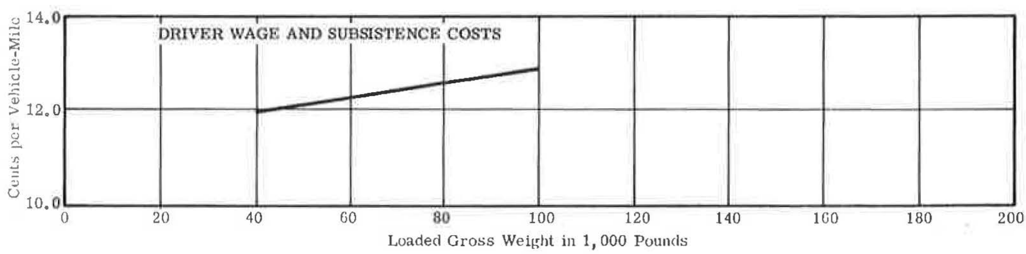

Figure 12. Gasoline engine powered combinations.

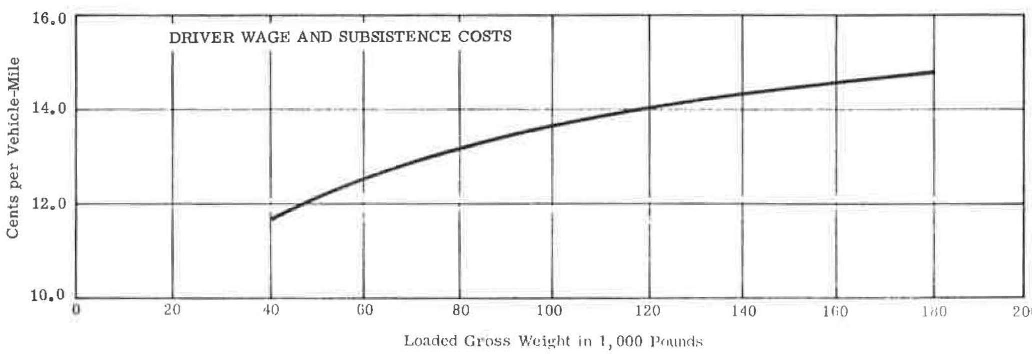

Figure 13. Diesel engine powered combinations.

Depreciation and Interest Costs

In the 1956 cost study (3), the depreciation costs calculated for the line-haul revenue trailer combinations constituted the major part of the expense. Each of the two general types of power vehicles, i.e., those with gasoline engines and those with diesel engines, were classified into three groups with different engine sizes. For gasoline engined tractors values developed for typical service lives to junk varied between 7.4 and 8.5

TABLE 2

LINE-HAUL, INDIRECT EXPENSES, COST PER TRAILER COMBINATION MILE[a]

Indirect Expense Account		1956 Total Amount ($)	1962 Total Amount ($)
Maintenance supervision	(4110)	5, 257, 228	9, 639, 848
Maintenance office and other expenses	(4120)	345, 582	615, 435
Other maintenance expenses	(4180)	6, 252, 057	9, 968, 123
Transportation supervision	(4210)	16, 529, 453	23, 648, 712
Transportation office and other expenses	(4220)	956, 650	1, 122, 747
Insurance and safety supervision	(4510)	5, 533, 097	8, 556, 938
Insurance and safety office and other expenses	(4520)	1, 899, 737	2, 241, 596
Insurance and safety public liability and property damage	(4530)	17, 468, 047	18, 593, 080
Insurance and safety workmen's compensation	(4540)	9, 212, 062	13, 131, 496
Insurance and safety tire, theft and collision	(4560)	3, 708, 405	3, 591, 210
Insurance and safety other department expenses	(4570) (4580)	1, 053, 479	251, 496
Salaries, general officers	(4611)	21, 545, 570	19, 624, 881
Salaries, other general office employees	(4613)	17, 348, 313	18, 502, 864
Salaries, expenses—general officers	(4621)	3, 897, 369	3, 223, 217
Salaries, general office employees	(4622)	711, 290	715, 331
Salaries, other general office expenses	(4623)	7, 557, 720	10, 658, 859
Employee's welfare expenses	(4145) (4245) (4545)	21, 300, 503	37, 512, 701
Social security taxes	(5240)	16, 191, 412	33, 957, 562
Real estate and property taxes	(5230)	3, 804, 967	6, 298, 191
Total		160, 572, 941	221, 854, 287

[a]Total owned vehicle-miles: 1956 = 1, 712, 129, 225 mi; 1962 = 2, 040, 395, 692 mi. 1962 expenses, $0. 1087; 1956 expenses, $0. 0938; constant upgrading unit applied to cost curves, $0. 0149.

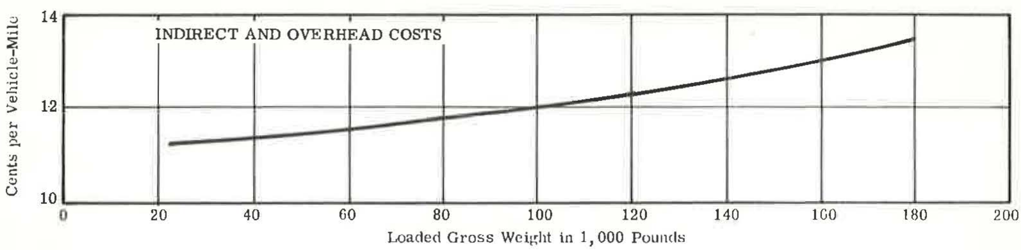

Figure 14. Gasoline and diesel engine powered trailer combinations.

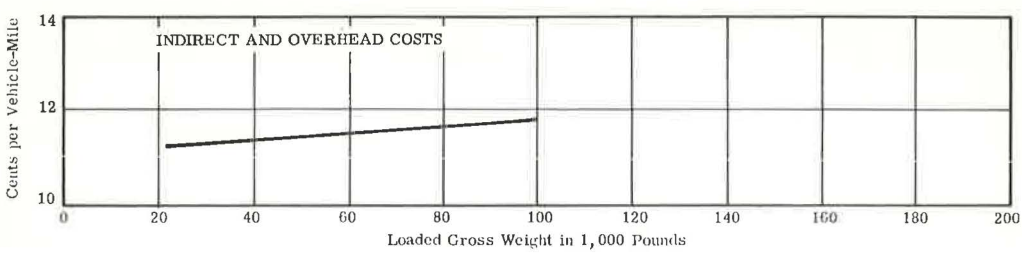

Figure 15. Gasoline engine powered trailer combinations.

yr, with the heavier gross combination weight tractors having the longer lives. Similar values developed for diesel engined tractors were between 7. 9 and 10. 6 yr.

These service lives are assumed unchanged for the 1964 study; however, because of increases in new purchase prices, the dollar amount of depreciation is somewhat greater. Other property subject to depreciation is assumed to have the same service life now as in 1956, but the current prices of new and improved shop and office facilities can be assumed to be higher than in 1956. Hence, depreciation costs may be higher now than in 1956.

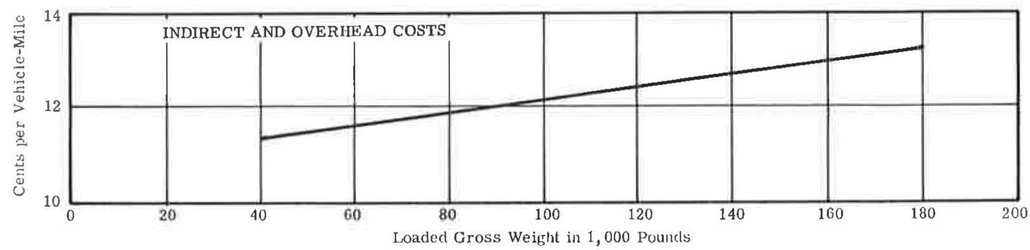

Figure 16. Diesel engine powered trailer combinations.

In the 1956 study (3), the charts showing Depreciation and Interest Costs included an interest cost for the undepreciated property which included interest paid on borrowed money and dividends paid to stockholders. It was assumed that funds to cover the undepreciated property of motor carriers came from these two sources, and therefore was paid for annually. The value of depreciated property was assumed as the amounts taken from the gross revenue and accumulated in depreciation accounts for the replacement of worn out and discarded property of any type, including motor vehicles and other real or personal property.

To upgrade the Depreciation and Interest Costs charts, the total amounts in the depreciation, interest and dividend accounts in Tables 5 and 8 of the ICC Transport Statistics for 1956 (3) and 1962 (4) were summarized (Table 3). The summary totals for each year are divided by appropriate power unit vehicle-miles from Table 14 of the ICC Transport Statistics to develop vehicle-mile costs for these three cost accounts.

The upgraded figures for Depreciation, Interest and Dividend Costs are shown in Figures 17, 18, and 19.

Summation of Costs

Figures 21, 22, and 23 of HRB Bulletin 301 include strata-type Summation of Costs charts in which the lowest curve represents the initial cost relationship, and each succeeding upper curve is an accumulation of the preceding groups of costs, leading to the topmost curve of the series which shows the Gross Operating Costs in relation to loaded gross weights of trailer combinations. Summation of Costs charts are made for the three major groupings of vehicles: (a) all trailer combinations (gasoline engine and diesel engined powered), (b) gasoline engine powered trailer combinations, and (c) diesel engine powered trailer combinations.

TABLE 3

DEPRECIATION AND INTEREST COSTS[a]

Item	1956 ($)	1962 ($)
Depreciation total	72,151,893	99,139,177
Interest total	9,324,471	15,892,166
Dividend total	6,315,219	11,201,447
Total	87,791,583	126,232,790
Average vehicle-mile costs	0.0545	0.0644

[a]Power unit vehicle-miles, owned vehicles: 1956 = 1,609,849,389 mi; 1962 = 1,958,930,439 mi.

$$\frac{\text{1962 unit cost}}{\text{1956 unit cost}} = \frac{0.0644}{0.0545} = 1.182 \text{ upgrading factor}$$

For the purpose of developing annual overall costs of highway freight transportation using the number of trailer combinations and loaded gross weights that may be predicted at any future time, the Summation of Costs curve for all trailer combinations (gasoline and diesel engine powered combined) provides the most accurate means of analysis, because the sample of data in the combined group is the largest. Further, a mixture of gasoline and diesel engine powered trailer combinations is more representative of the nature of the fleet actually in use in the United States. The distribution of trailer combinations by engine type has undergone noticeable change since 1956 because of the replacement of many gasoline engines by diesel engines in line-haul service. Detailed

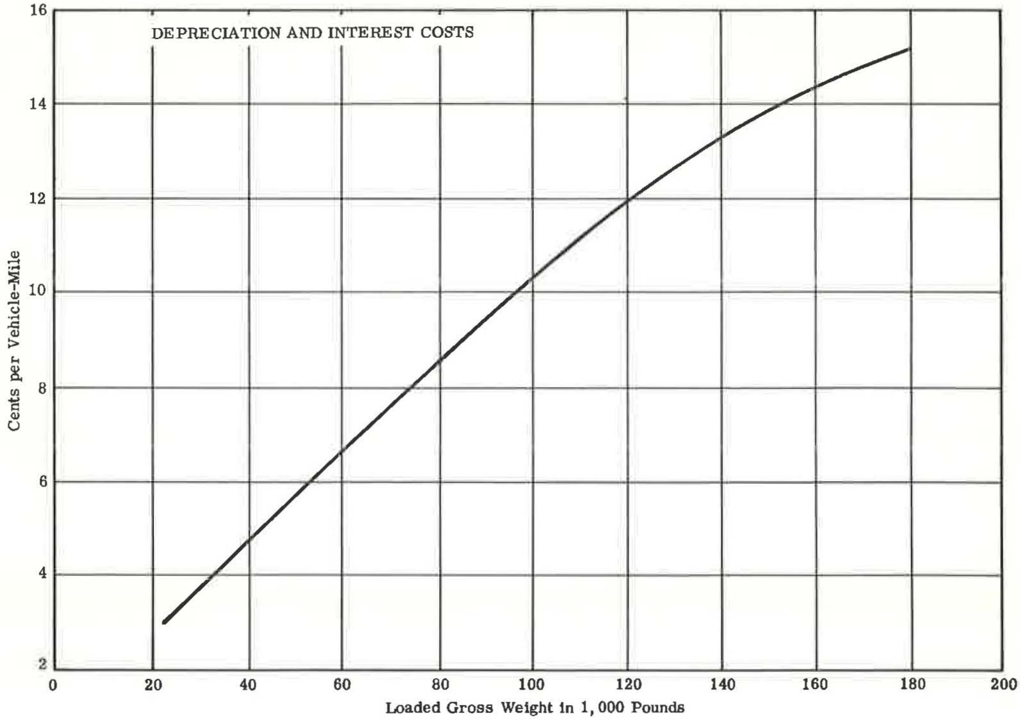

Figure 17. Gasoline and diesel engine powered trailer combinations.

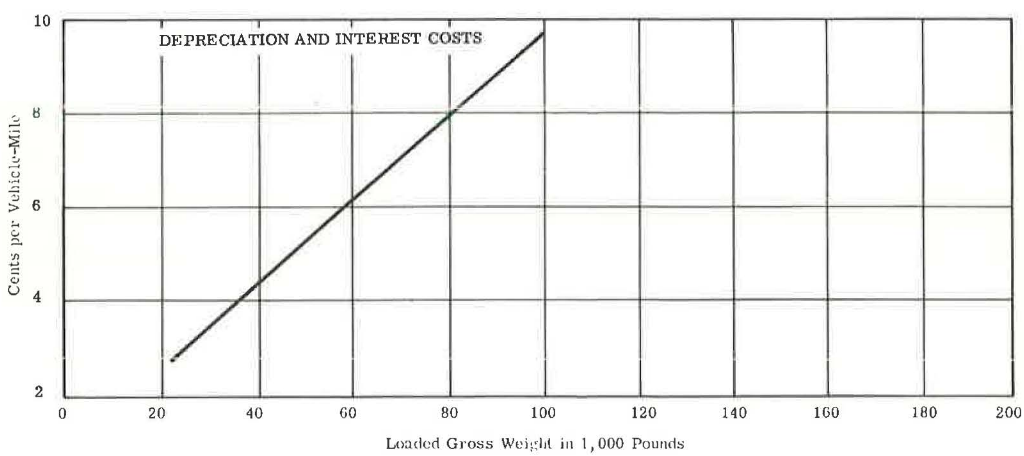

Figure 18. Gasoline engine powered trailer combinations.

statistics on intercity trailer combinations are not readily available to show the extent of this change. However, the differences in Summation of Costs between each engine type and the combined type costs are not substantial. Therefore, the numerical differences between gasoline and diesel engine combinations are not a critical factor. This supports the premise that the Summation of Costs for the combined fleet should be used in any prediction calculations.

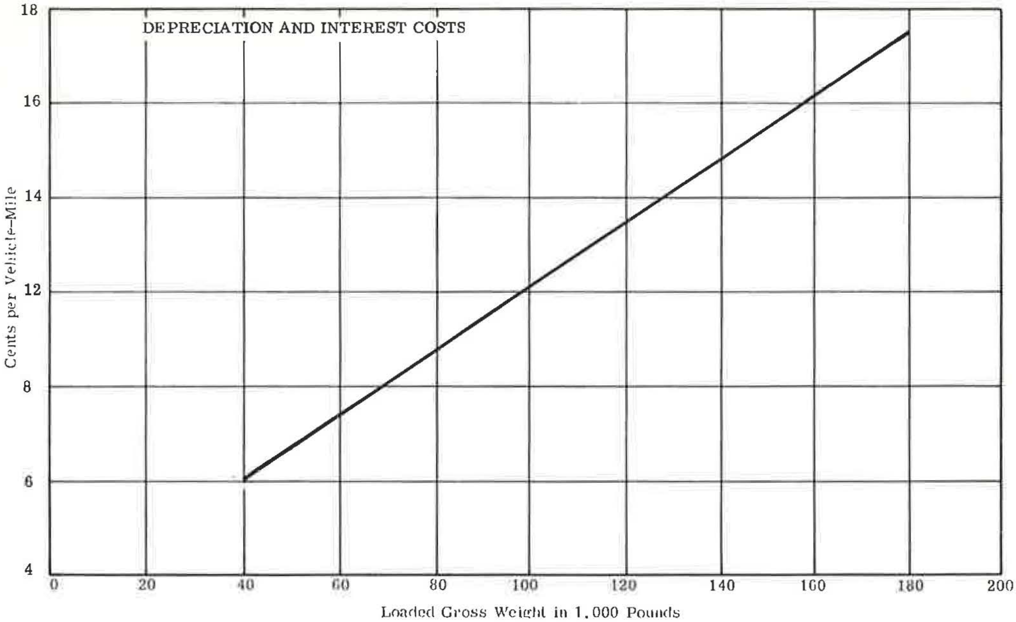

Figure 19. Diesel engine powered trailer combinations.

The Summation of Costs for 1964 are shown in Figures 20, 21, and 22. The cost elements included in each strata-curve are explained in pages 43 and 44 of the HRB Bulletin 301.

GROSS OPERATING COSTS AND TON-MILE COSTS FOR ALL TRAILER COMBINATIONS

Vehicle-Mile Costs

The upgraded gross operating costs per vehicle-mile for all trailer combinations (gasoline engine powered and diesel engine powered combined) shown in Figure 20 are replotted in Figure 23, which is similar to Figure 18 in HRB Bulletin 301. The new vehicle-mile costs were divided at each 20,000-lb loaded gross weight ordinate by the same payload weights (for given gross weights) shown in Figure 15 of HRB Bulletin 301.

The reported line-haul operating costs of trailer combinations are related to the loaded gross weights of the trailer combinations. The definition of loaded gross weight in HRB Bulletin 301 is as follows:

> The loaded gross weight is the predominant loaded operating weight of a vehicle or trailer combination. The loaded gross weight includes the empty (tare) weight of the vehicles, plus the payload (cargo) weight when the cargo body is fully loaded; that is, fully loaded in regard to the stowage capacity of the cargo body for light-density commodities, or to the maximum permitted gross vehicle weight when loaded with heavier commodities.

The payload weights are the typical or modal payloads as hauled by the individual carrier. This definition indicates that the loaded gross weights of each class of trailer combination may vary over a considerable range. The 2-S1 class of trailer combinations may have a wider range than the multi-axle trailer combinations that are usually

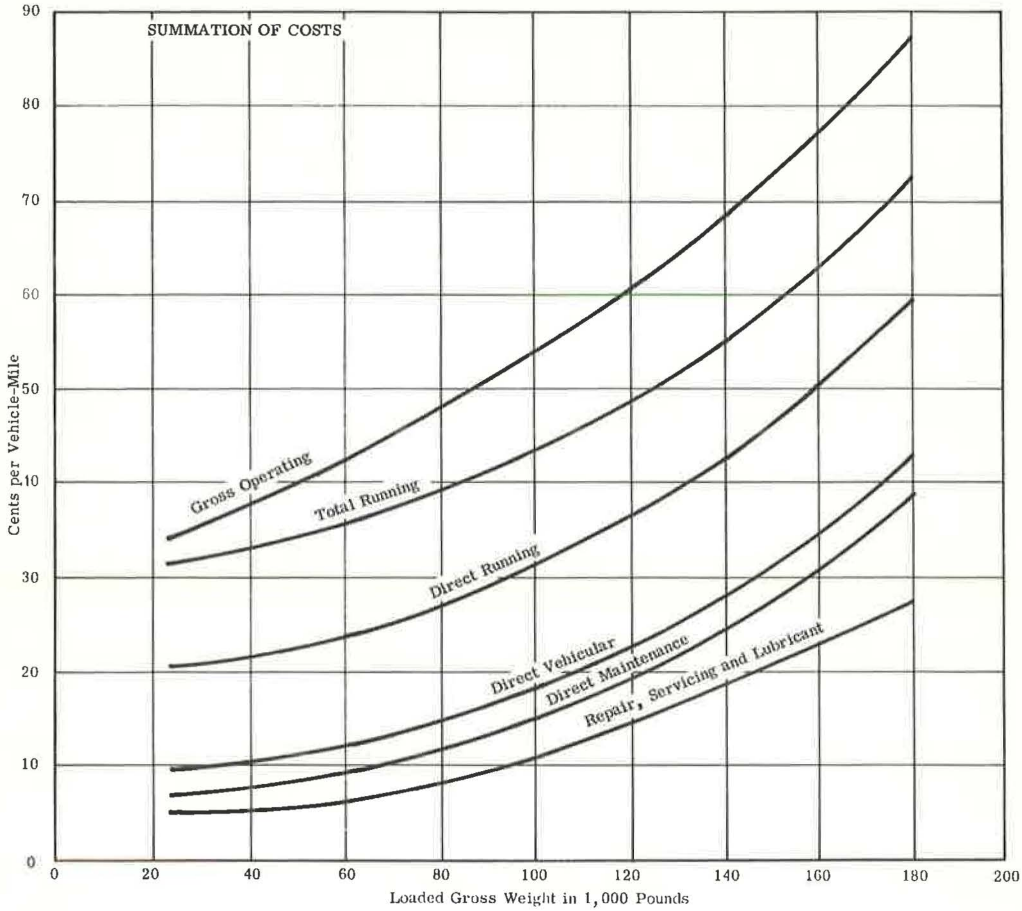

Figure 20. Various costs per vehicle-mile for gasoline and diesel engine powered trailer combinations, by loaded gross weight.

used for the heavier commodities. The original cost data were analyzed on the basis of the predominant loaded gross weights in each carrier's records.

The carriers' records were always investigated on the basis of round trips, which may include empty return travel, because it is customary in the trucking industry to domicile power vehicles at specific terminals to control maintenance, overhauls, and costs. It is always necessary to return the vehicle to its domicile terminal to have it available for the next outbound trip. Thus a consistent measure of work rate was the actual loaded gross weights regularly obtained in a fleet.

The main possible source of any differences in costs between loaded and empty operations is in fuel and tires. Other costs are affected to little or no measurable extent by the degree of cargo loading. However, as carriers' cost records are for round trip operation, the differences in travel measurable from carriers' records are (a) loaded in both directions (i.e., 2 loaded trips in a round trip), (b) loaded in one direction and empty on return trip (i.e., 2 trips, one loaded and one empty in a round trip), and (c) loaded in one direction with intermediate degrees of loading on the return trip (i.e., 2 trips in a round trip). The results of segregating fuel costs into five levels of trips between loaded in both directions and loaded in one direction with various degrees of loading or no load on the return are shown in Figures 40 and 41 in HRB Bulletin 301. There were insignificant differences in fuel costs for the different levels of trip loadings.

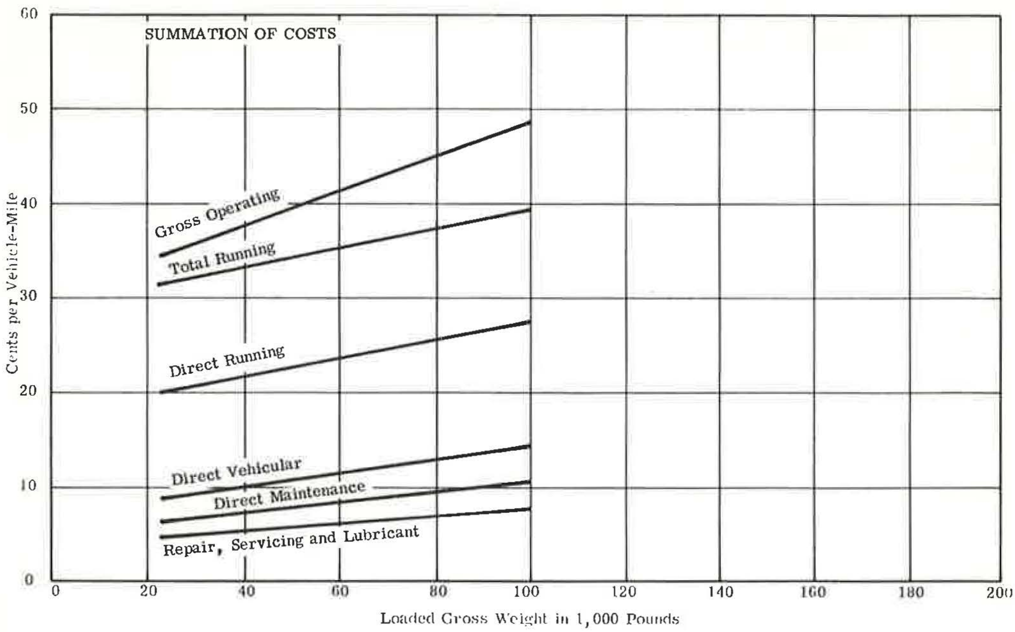

Figure 21. Various costs per vehicle-mile for gasoline engine powered trailer combinations, by loaded gross weight.

The most accurate data for operating costs are shown in Figure 18 of HRB Bulletin 301 and Figure 23 of this report, which include all trailer combinations for which data were obtained. The data for all trailer combinations include both gasoline engine and diesel engine power vehicles.

Other figures in HRB Bulletin 301 show, to a degree, cost differences between different classes of trailer combinations for certain cursory comparisons between classes of trailer combinations. However, these samples of trailer combinations and cost data are smaller and the curves are less reliable for estimating total overall freight transportation costs than the summation of costs for all trailer combinations.

Since the line-haul operating costs are related to loaded gross weights, there is a problem in developing operating costs for trailer combinations traveling empty, or with little payload. The seriousness of this problem can be appreciated from the annual U.S. Bureau of Public Roads-state truck-weight studies (6), which indicate that approximately 33 percent of all trailer combinations on the main rural roads are without payload.

For empty trailer combinations it is recommended that assumed loaded gross weights be assigned by axle classification of trailer combinations. Suggested loaded gross weights to be assigned for cost purposes to different axle classifications of trailer combinations are given in Table 4.

These loaded gross weights were selected arbitrarily to take into account the differences in axle and gross weights permitted on rural primary roads in various states, and on the toll roads permitting 95- to 105-ft long double trailer combinations.

Ton-Mile Costs

The lowest ton-mile curve in Figure 23 is the ton-mile cost when payload is carried in both directions. The upper curve, the cost values of which are twice that of the lower curve, shows the ton-mile costs when the payload is carried in one direction only and the cargo space is empty on the return trip. The vehicle-mile costs for different degrees of loadings lie between these two extremes.

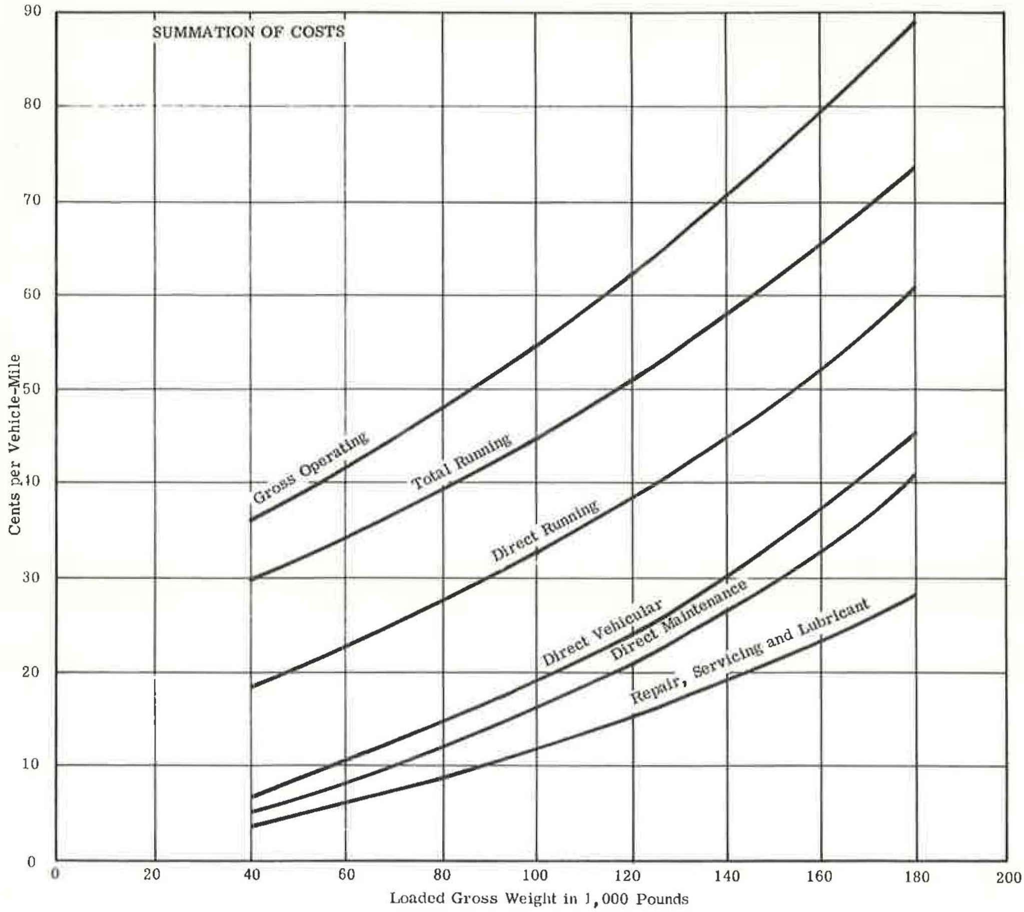

Figure 22. Various costs per vehicle-mile for diesel engine powered trailer combinations, by loaded gross weight.

The average ton-mile costs for the different loaded gross weight trailer combinations may be estimated using percentage values from the annual U. S. Bureau of Public Roads-state truck-weight data. For a number of years, truck-weight studies have indicated that approximately 67 percent of vehicles weighed were with cargo, and 33 percent were empty. Although there may be some error in assuming that all vehicles "with cargo" were fully loaded, this assumption is nevertheless supported, for practical purposes, by the discussion regarding directional characteristics of freight haulage as indicated in Tables 35 and 36 and adjoining text in HRB Bulletin 301.

Therefore, it is assumed that the averages of the loadings of all trailer combinations, as counted in the traffic stream, are 67 percent of the fully loaded payload for each level of loaded gross weight. Thus, taking this 67 percent of the maximum payload per loaded gross weight (Fig. 15, HRB Bulletin 301), and dividing this reduced payload into the gross vehicle-mile cost at each 20,000-lb ordinate gives a new curve of practical average ton-mile costs for trailer combinations of various loaded gross weights of vehicles in the traffic stream. These data are plotted as the ton-mile curve between the upper and lower ton-mile curves, and are labeled "payload ton-mile—average loading." This average cost includes all empty miles, and permits a calculation of total transportation costs from the number and mileage data for trailer combinations of various levels of loaded gross weights, length of haul, directional char-

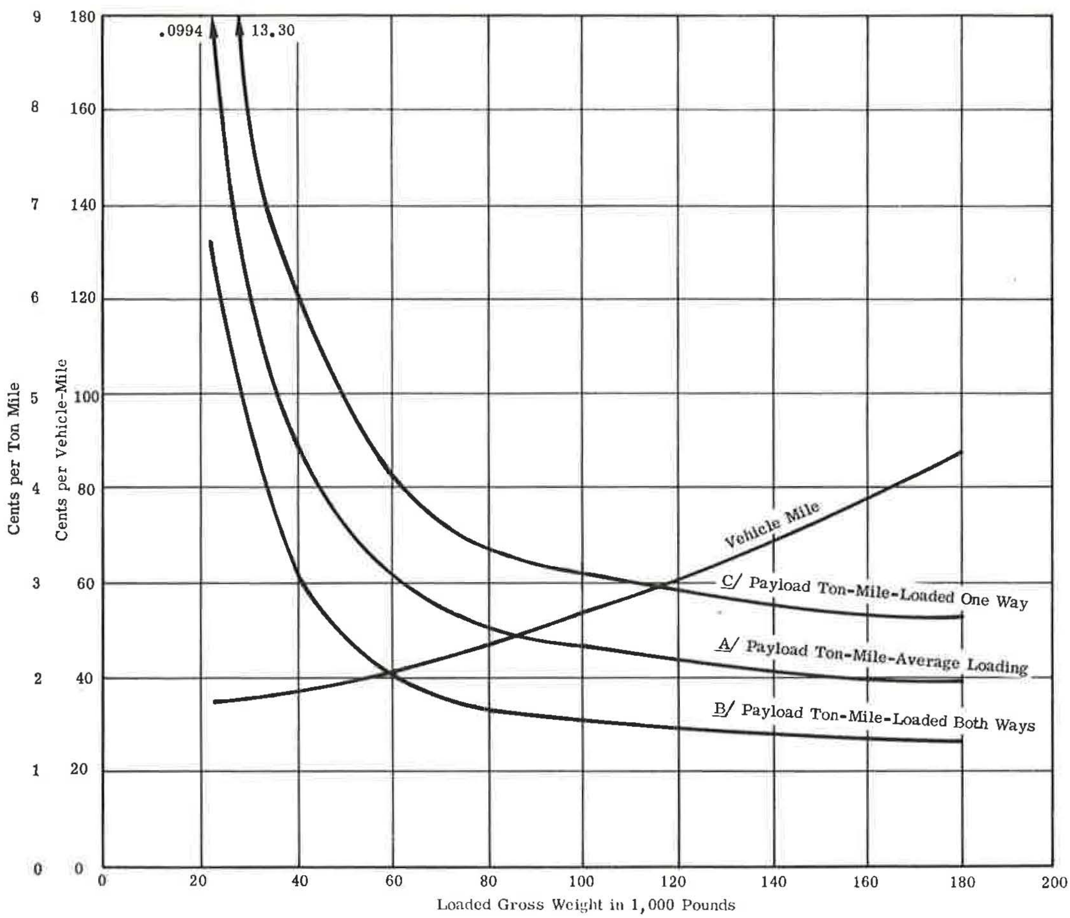

Figure 23. Gross operating costs for all trailer combinations, showing vehicle-mile costs and payload ton-mile costs in relation to loaded gross weights. Payload ton-mile costs are shown: A/ for average operations which include the ratio of payloads (empty) as found in present traffic rural roads, B/ for operations with payloads in both directions, and C/ for operations with payload in one direction and no-load (empty) on return.

acteristics of haulage, and the tonnages of freight and lengths of haul that may be predicted for the future.

TABLE 4

SUGGESTED LOADED GROSS WEIGHTS FOR ASSIGNING COSTS TO EMPTY TRAILER COMBINATIONS

Trailer Comb. Axle Class.	Sugg. Loaded Gross Wt (lb)
2-S1	44,000
2-S2	58,000
2-2	62,000
3-2	72,000
3-S2	72,000
2-S1-2	72,000
3-S2-3[a]	120,000
3-S2-4[a]	130,000

[a]For toll road service.

TRANSPORTATION SAVINGS RESULTING FROM HEAVIER GROSS WEIGHTS

In addition to savings in vehicle transport costs resulting from higher gross weights, heavier permitted gross weights and larger permitted cubical dimensions would also reduce the number of freight vehicles in the traffic stream. With the predicted increase in motor vehicles, especially passenger cars, the factor of highway space for vehicles will become increasingly important. There appears little likelihood of a reduction in the number of passenger cars, as they are a matter of individual and personal selection, comfort, and convenience. On the other hand, the number of highway freight trailer combinations, which primarily serve the needs of the general public and business, could be reduced by means of larger vehicles and greater cargo weights, both of which would increase the efficiency of highway freight transportation.

For example, for light-density commodities of under 25 pcf, the reduction in the number of trailer combinations for line-haul service would be almost directly proportional to the increase in cargo space.

For heavier density commodities, the reduction in the number of trailer combinations would be directly proportional to the increase in permitted cargo payload weights above the present permitted payload and gross weights.

The savings in transport costs to be gained by increasing permitted gross weights can be estimated by assuming a reasonable number of ton-miles as a possible day's work for a trailer combination. A typical large trailer combination is capable of handling approximately 10,000 ton-mi a day in line-haul service. Therefore, a reasonable day's work for a line-haul trailer combination is assumed to be 10,000 ton-mi. This amount of service may be calculated by assuming that a trailer combination having a gross weight of 60,000 lb can haul 20.5 tons of freight 488 mi in 24 hr. A ton-mile cost of $0.0205 was selected from Figure 23 for a 60,000-lb loaded gross weight trailer combination. This combination, loaded in both directions, with a payload of 20.5 tons, was used for multiplying the ton-mile cost of $0.0205 by 10,000, the estimated daily ton-miles, which produced a cost of $205.00. This figure becomes a basic cost against which other daily costs are compared.

Using the same procedure for an 80,000-lb loaded gross weight vehicle hauling a 28.0-ton payload, 358 mi, a daily cost for 10,000 ton-mi is $168.00. The difference in these costs represents the daily saving possible per trailer combination with increased permitted gross weight.

Table 5 gives similar calculations for loaded gross weight trailer combinations of up to 160,000 lb. There is initially a significant reduction in vehicular operating costs, but as the permitted gross weights increase, the savings become less significant. At the 160,000-lb level, the daily savings appear to reach the end point in diminishing returns and provide too little savings to offset increasing costs of highways of higher load-carrying capacity.

Future Highway Transport Potential

Personal observations this summer on the New York Thruway showed that 500 veh-mi were regularly attained on this divided expressway within a 10-hr driving shift, with double trailer combinations 98 ft in length and with gross weight up to 128,000 lb.

TABLE 5

LOADED GROSS WEIGHTS OF TRAILER COMBINATIONS, AVERAGE PAYLOADS CARRIED, AND COST REDUCTIONS RESULTING FROM HEAVIER VEHICLE GROSS WEIGHTS

Loaded Gross Wt (lb)	Avg. Payload (tons)	Cost/10,000 Ton-Mi ($)	Savings from Heavier Gross Wt ($/10,000 ton-mi)
60,000	20.5	205	
80,000	28.0	168	37.00
100,000	34.0	156	12.00
120,000	40.0	150	6.00
140,000	49.0	139	11.00
160,000	58.0	133	6.00

TABLE 6

NUMBER OF TRAILER COMBINATIONS OF VARIOUS LEVELS OF LOADED GROSS WEIGHTS REQUIRED TO MOVE 1,000,000 TON-MILES OF FREIGHT 488 MILES A DAY

Permitted Gross Wt (lb)	Avg. Payload (tons)	Avg. Daily Ton-Mi/ Trailer Comb. (ton-mi)	No. of Trailer Comb. Required	No. of Cargo Bodies in Trailer Comb.
60,000	20.5	10,000	100	1 40-ft
80,000	28.0	13,664	74	1 40-ft
100,000	34.0	16,592	61	1 40-ft
120,000	40.0	19,520	52	2 40-ft
140,000	49.0	23,912	42	2 40-ft
160,000	58.0	28,304	36	2 40-ft

One example was a turnaround from Syracuse, N.Y., to Suffern, N.Y., a distance of 508 mi, and with a 40-ton payload gave 20,300 payload ton-miles of freight transport. This run was accomplished in an 11.25-hr on-duty period, which included exchange of both trailers at Suffern, and necessary driver's business and personal stops en route.

Another way of estimating the advantages of various higher levels of loaded gross weights is to calculate the number of trailer combinations of higher loaded gross weights that would be required to haul 1,000,000 ton-mi of freight daily. Starting with a basic trailer combination of 60,000-lb loaded gross weight, which is assumed to be capable of hauling 10,000 ton-mi a day over an average length of haul of 488 mi, and would require 100 trailer combinations, the numbers of trailer combinations of higher levels of loaded gross weights are given in Table 6. These estimates apply only to the heavier commodities capable of heavier loads in the permitted sizes of cargo bodies.

Other measures of the operating advantages of heavier permitted loaded gross weights can be devised, but Tables 5 and 6 give two measures of the advantages which may tend to offset the higher construction costs of highways with greater load-carrying capacities.

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5. 1964 National Over-the-Road Drivers Wage Contract. Jan. 1964.
6. U.S. Bureau of Public Roads. Table HT-1, Travel and Weight Characteristics of Trucks and Combinations. Highway Statistics, 1960 to 1962.