Several major conclusions can be drawn from these points.

The first conclusion is that, in order for the amount of illegal truck overweighting to be reduced, the effectiveness of enforcement programs must be increased. The probability of being weighed and the expected cost of the fine should, when combined, be greater than the incentives to overweight. The analysis performed in this paper indicates that in most cases the present enforcement programs are inadequate and in need of revision. The fine structure should be more realistic and take into account the expected value of being caught, the value of the overweight, and the number of miles traveled. The probability of being weighed could most effectively be increased by making fixed scales difficult to avoid and by making greater use of portable scales.

The second major conclusion is that the cost of overweight permits does not reflect the additional pavement damage caused by overweighting. To provide a more appropriate permit fee, the cost of the permit should take into account the amount of the overweight and the number of miles traveled.

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Abridgment

Impact of Increased Truck Weights on Relative Costs of Motor Carriers and Railroads and Potential Modal Diversion

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The relative costs per ton-mile for rail boxcar, trailer-on-flatcar (TOFC), irregular-route motor carriers, and exempt owner-operators for the period 1977-1985 are examined. A specific rate of inflation was applied to each category of cost in 1977 for the four types of transportation service to determine the effect of inflation to 1985. The relative average freight costs per unit of output were then compared at truck gross vehicle weight limits of 73 280 and 80 000 lb. The principal finding of the study is that any shift in the average costs per ton-mile resulting from an increase in the truck weight limit is influenced by the impact of inflation on the various cost components. A comparison of the relative costs by type of service and mode suggests that inflation may have a more adverse impact on the railroads than on motor carriers of truckload freight. The analysis also indicates that, over the long term, the position of TOFC relative to truckload motor carriage could deteriorate because TOFC costs have been increasing faster than comparable truckload costs. Based on the economic factors specified and analyzed in this study, TOFC is not the preferred transport option over the 1981-1985 period.

There is a perception held by some people that the use of the more productive truck carrying dimensions would divert traffic from rail by lowering unit costs and thus upset the competitive truck-rail balance (1). However, since 1977 rapidly escalating prices for all factors of production have affected the unit costs of the modes differently. Liberalized truck size and weight limits, which allow greater productivity to occur (2), will dampen the influence of inflation on truck costs both for the motor carrier industry and for that segment of the rail industry that depends on truck service--i.e., trailer-on-flatcar (TOFC). Thus, such limits will benefit the shipping public by way of decreased costs without harm or prejudice to any mode.

STUDY METHODOLOGY

The analysis presented in this paper is based on a cost model developed by the U.S. Department of Transportation (DOT). In a technical supplement (3), DOT estimated the values of the various functional cost inputs (such as labor and fuel) for several types of truck and rail service for the year 1977. The results of the cost model were then used by DOT to support its conclusions in its report, "An Investigation of Truck Size and Weight Limits" (4). (DOT did not account for the terminal and overhead costs of irregular-route carriers. Therefore, adjustments were made in the DOT line-haul expense and overhead and terminal expenses were created. DOT also did not analyze exempt owner-operator costs. Therefore, irregular-route truckload line-haul costs were used to approximate these costs. Although exempt owner-operators have overhead expenses, they act as if they have only line-haul expenses.)

To project the DOT 1977 costs through 1985, each functional cost is inflated at an individual economically and historically justified rate. The estimated relative average unit freight costs for 1981 and 1985 reflect the effect of inflation on truck and rail costs.

The projected unit costs reflect cost relations that exist under truck gross vehicle weight (GVW) limits of 73 280 lb. To complete the analysis, the projected DOT costs were then adjusted to an increased payload weight of 80 000 lb.

The analysis presented in this paper compares costs for the following types of service:

1. Motor carrier--Irregular-route, common carrier, full-truckload service using 45-ft tractor-semitrailers;
2. Owner-operator--Full-truckload service using 45-ft tractor-semitrailers;
3. Rail carrier--General box carload service; and

Table 1. Adjusted cost for various types of carriers.

Carrier Type	Cost ($) Payload at 20 Tons 1977	1981	1985	Payload at 22.5 Tons 1977	1981	1985
Railroad boxcar						
Line-haul ($/ton-mile)	0.015	0.025	0.039	0.015	0.025	0.039
Terminal ($/ton)	1.689	2.626	3.896	1.689	2.626	3.896
TOFC						
Line-haul ($/ton-mile)	0.027	0.046	0.071	0.025	0.041	0.064
Terminal ($/ton)	13.418	18.900	27.159	11.929	16.803	24.145
Irregular-route truckload[a]						
Line-haul ($/ton-mile)	0.041	0.064	0.097	0.037	0.058	0.088
Terminal ($/ton)	1.889	2.436	3.569	1.678	2.164	3.170
Exempt owner-operator[a]						
Line-haul ($/ton-mile)	0.041	0.064	0.097	0.037	0.058	0.088

[a]Explained in DOT technical supplement (3).

4. Rail carrier--Rail dedicated 40-ft TOFC service.

PROJECTIONS

DOT has estimated functional costs for rail boxcar, TOFC, and irregular route for 1977 (3). For rail boxcar and TOFC, costs are presented for three regions: East, South, and West. Irregular-route motor carrier costs are presented for four regions: Northeast, South, Midwest, and West. Nationwide average costs were developed by averaging the respective regions and then projecting the nationwide average cost to 1985.

Cost projections were based on historical reports plus expectations of future changes. In recent years the inflation rate has affected the costs of the major functional inputs unequally. Some costs, notably that of fuel, have increased at rates far in excess of others. As a result, the cost projections used in this analysis were based on differential inflation rates for each functional input. For purposes of consistency, all rates of change in costs were expressed as indices with 1977 as the base year.

Railroad costs were based on historical records published by the Association of American Railroads (5). The indices of cost changes were available for 1969-1979 (and, in some cases, 1980) for each functional area. In most instances, cost projections were generated by applying the average rate of change for the five-year period from 1975 through 1980 to the period 1981-1985. This approach assumes that the economic conditions for the five-year period of 1975-1980 will follow a similar pattern over the next five years.

Several sources were used to collect historical data for each cost function for the two motor carrier groups. In addition to references cited in this paper (6-11), these sources included the following:

1. Table 799, Producers' Price Index for Intermediate Materials, Supplies, and Components, from Statistical Abstracts (1967 = 100);
2. Intercity truckload driver compensation (residuals and salaries) reported by the National Motor Transport Data Base survey conducted by Transportation Research and Marketing of Salt Lake City, originally developed for the Association of American Railroads; and
3. The Comparative Fuel Price Report of the Household Goods Carriers Bureau, Arlington, Virginia, which is compiled monthly.

The methodology for projecting future inflation rates was the same as that used for rail.

PROJECTED TON-MILE COSTS WITH AND WITHOUT CHANGE IN TRUCK WEIGHTS

The average cost per mile or per ton provides little insight into competitive areas of traffic or potential diversionary effects of increased truck weights. In this study, therefore, the comparisons among the four service types were based on cents per ton-mile at various lengths of haul.

However, because of the limitations and the incompatibility of the data, certain adjustments were made in the ton-mile costs. For example, adjustments were made in the average loadings for TOFC, irregular-route carriers, and exempt owner-operators to reflect costs at 73 280 and 80 000 lb GVW. Adjustments were also made in the mileages to account for circuity in comparing lengths of haul. Table 1 presents the 1977, 1981, and 1985 total costs per ton-mile for each of the four carrier types.

EFFECT OF INCREASED WEIGHT ON TRUCK-RAIL COMPETITION

To determine the likely extent of modal competition, the costs per ton-mile were then computed for various lengths of haul for each carrier group. Subsequently, these costs were plotted on graph paper to see at what length of haul (if any) the cost curves intersect. A more precise way to determine whether and where the cost curves intersect was to solve simultaneous equations for length of haul. Equation 1 was used to determine where, for example, the average length of haul of TOFC equals that of irregular-route truckload carriers.

$$\text{(TOFC terminal cost}/X) + \text{TOFC line-haul costs per ton-mile} = (\text{irregular-route overhead costs}/X) + \text{irregular-route line-haul costs per ton-mile} \quad (1)$$

where X is the average length of haul. In 1977, for example, TOFC and irregular-route costs intersected at 824 miles.

The lengths of haul at which the cost curves intersect for 1977, 1981, and 1985, with and without any change in GVW, are given below:

Category	Length of Haul (miles) At 20 Tons	At 22.5 Tons
TOFC versus irregular-route truckload		
1977	824	854
1981	915	861
1985	907	874
TOFC versus exempt owner-operator		
1977	968	994
1981	1050	988
1985	1044	1006

Rail boxcar is not presented because the cost curves intersect at extremely short lengths of haul. If shippers are using truckload motor carrier service instead of rail boxcar service at distances greater than 50 miles, it is for reasons other than ton-mile costs, such as lower physical distribution costs and improved service.

FINDINGS

In this analysis, the projected relevant costs of rail boxcar, rail TOFC, irregular-route motor carriers, and exempt owner-operators were determined by assuming a change in truck weights from 73 280 to 80 000 lb. The analysis considered the impact of increased gross weights on ton-mile costs and the influence of inflation on the relative costs of four carrier groups.

It was found that inflation has affected motor carriers and railroads differently. For example, in 1977 irregular-route truckload carriers had lower costs than TOFC up to 824 miles. By 1981, the truckload carriers had a cost-per-ton-mile advantage up to 915 miles. However, with increased weights, TOFC would be able to overcome, in part, the effects of inflation. For example, in 1981, with increased weight, the irregular-route carriers and TOFC had similar costs at 861 miles rather than 915 miles.

The analysis also indicated that, although fuel costs were lower for TOFC than for truckload motor carriers, on both absolute and percentage of total cost bases, the long-run total-cost-factor position of TOFC is deteriorating in comparison with truckload motor carriage. For example, by 1985 TOFC line-haul costs will have increased by 165 percent and TOFC terminal costs will have increased by 102 percent. The comparable cost-factor increases for irregular-route truckload carriage are 139 and 90 percent, respectively. Over the 1981-1985 period, the economic factors examined in this paper indicate that TOFC is not the market-preferred investment.

Finally, it must be remembered that the initial assignment of costs to particular functional areas was performed by DOT. This paper assumes that those costs were properly assigned. In addition, it should be noted that both we and DOT rounded certain arithmetic values that may have influenced the conclusions.

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Abridgment

Truck Forecasts and Pavement Design

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The uncertainties associated with making design load estimates for use in determining pavement structure requirements are many. A brief discussion of the problem of estimating the present or base-year annual average daily load on an existing route or alignment is presented. The discussion focuses on the five-axle tractor-semitrailer, which is regarded as causing more than 80 percent of traffic-attributable pavement damage on Minnesota's Trunk Highway System.

The AASHO Road Test provided the basis for relating the pavement deterioration resulting from any given axle load, single or tandem, to that resulting from an 18-kip dual-tire single axle. It also provided the basis for the design of both flexible and rigid pavement structures in terms of the number of equivalent 18-kip single-axle loads the pavement can be expected to carry before reaching a preselected terminal serviceability level. The Minnesota Department of Transportation (Mn/DOT) has been using the