

Economic Factors of Developing Fine Schedules for Overweight Vehicles in Texas

MARK A. EURITT

A rapid deterioration of the state's highway network can have serious economic consequences for Texas. Many communities depend entirely on the trucking industry for the transport of goods to principal markets. In order to protect the structural integrity of the highway system, which represents a significant economic investment, statutes limit the gross weight and axle weights of vehicles. However, despite the illegality of an overloaded vehicle, a large number of trucks operating on Texas highways exceed their maximum allowable weights. These illegal operations deprive the state of nearly \$48 million per year. The current schedule of fines and penalties is wholly inadequate. By its very structure it encourages rather than discourages overweight violations. Truck operators have merely accepted these penalties as a cost of doing business. An operator of a 120,000-lb, 18-wheel vehicle, for example, has a \$2,621 incentive to operate above the 80,000-lb legal gross weight limit. The low probability of being caught and the small fine fail to discourage a decision to overload a vehicle.

Road transport has become the predominant mode for domestic freight, outstripping the rail industry in this respect. In the state of Texas, nearly two-thirds of the communities depend entirely on trucks for the transporting of goods to principal markets (1). The construction and maintenance of highways is thus central to the economic well being of the trucking industry and to the state's communities. A rapid deterioration of the state's highway network could have serious economic ramifications.

The construction and maintenance of highway facilities requires a significant economic investment. Since 1980, the Texas State Department of Highways and Public Transportation (SDHPT) has spent an average of \$1.5 billion per year on construction and maintenance of state highways (2). The SDHPT's 1982 strategic plan indicated a need of \$57.6 billion (in 1982 dollars) for highway facilities over the next 20 years (3). In order to protect the structural integrity of the highway system, statutes limit the size and weight of motor vehicles. These limitations have significant (and opposite) effects on the trucking industry and the state highway system. Reduction of operating costs is an important objective in trucking operations; increases in the per vehicle payload through increases in the size and allowable weight of trucks can yield considerable productivity benefits and reductions in unit shipping costs. These savings, however, are achieved at the expense of damage to the state's pavements and bridges, the amount depending on the number and weight of resulting axle passages, because increases in vehicle operating weights result in a more rapid deterioration of highway facilities.

In recent years, state transportation agencies have become concerned with their ability to generate sufficient resources to

maintain adequate service levels for highways. Because of the impact of vehicle weights on highways and structures, load limitation statutes regulate vehicle operating weights. In Texas, the legislature has set the maximum gross vehicle weight at 80,000 lb, the maximum single-axle load at 20,000 lb, and the maximum tandem-axle load at 34,000 lb. Exceptions to these limits are allowed for vehicles operating with a special permit or those operating under special legislation (e.g., ready-mixed concrete trucks and vehicles transporting seed cotton modules, fertilizer, milk, poles, piling, unrefined timber, electric power transmission poles, cotton, and unladen lift equipment). In this paper, overweight vehicles operating illegally are emphasized. Figure 1 shows the number of reported weight violations in the years 1981–1984 (unpublished data, Texas Department of Public Safety).

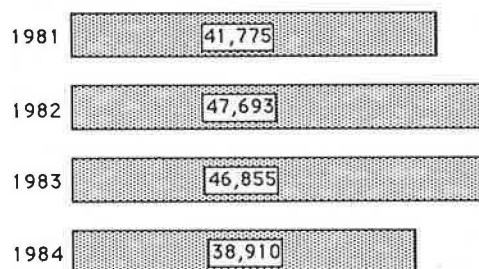


FIGURE 1 Number of overweight violations (unpublished data, Texas Department of Public Safety).

The economic implications of overweight vehicle operations are important to the state of Texas. Analysis of the Texas Truck Weight Survey reveals that the number of overweight operations ranged from 21 to 25 percent for all truck operators in 1984 (4). If the state is to maintain a viable highway network, the effects of overweight vehicle operations must be documented. In this paper, economic damages to the Texas highway system and economic benefits to the trucking industry are noted. In addition, the economic implications of fines resulting from the vehicle weight laws are reviewed and an alternative fine schedule is presented. From this discussion, policy makers and analysts may gain a greater appreciation for the magnitude of the effects of overweight vehicle operations.

ECONOMIC IMPLICATIONS OF OVERWEIGHT VEHICLES

There are two major factors associated with overweight vehicle operations: (a) the economic cost resulting from damage to

highway facilities, and (b) truck operating profits. A vehicle operating above its allowable weight in effect is stealing life from the roadway. Increased wear and tear on a roadway requires earlier repairs or replacement to the structure and can adversely affect a state transportation budget. On the other hand, adding weight to a vehicle has little effect on the operator's costs, but increases the payload. The resulting extra profit can be passed on in the form of lower shipping rates that give the illegal operator an unfair rate advantage over competitors who obey the law. Combined, these two major factors present important problems for a state transportation system.

Economic Damages to Highway Facilities

Texas highway facilities are typically designed to last for about 20 years. In the highway planning stage, engineers design highways to withstand a specified number of passages by an axle of prescribed weight. A properly built facility given routine maintenance and traffic loads not in excess of designed capacity should last for 20 years. When a vehicle imposes a load on a highway greater than that for which the facility was designed, the life of the highway is reduced. Herein lies the nature of the damage caused by overweight vehicles; in essence, overweight vehicles steal life from the roadway.

The relationship of load to pavement damage was documented by the American Association of State Highway Officials (AASHO) [since renamed American Association of State Highway and Transportation Officials (AASHTO)] Road Test in 1962. The AASHO Road Test, conducted from 1958 to 1961 at a cost of \$30 million, was the most definitive work ever performed to determine the effects of truck size on pavements. The methodology used in the AASHO Road Test establishes the capability of converting any single-axle load to a standard load (generally, an 18,000-lb single-axle load) in terms of damage to the pavement (5). This process allows engineers to convert axle loads of various truck classifications into equivalent axle loads (EALs). Roadways are now designed to bear a specified number of EALs during their life.

The dependence of pavement damage on axle weight closely approximates an exponential relationship. Consequently, when axle weights are increased above a roadway's designed capacity, damage to the facility increases significantly. For example, an axle weight of 26,000 lb is only 30 percent greater than an axle weight of 20,000 lb, but the damage effect on the roadway is 200 percent greater. Similarly, a 3S-2 loaded to 80,000 lb weighs about the same as 20 automobiles, but impacts the roadway at an equivalence of 9,600 automobiles (6). (See Figure 2 for an illustration of the 3S-2 and other vehicles.)

Combining typical axle weight distributions with the AASHO EALs allows calculation of relative damage equivalencies and thus relative damage of overweight vehicles. Table 1 converts the AASHO EALs to an 80,000-lb standard 3S-2 combination vehicle. These data demonstrate, for example, that a single 110,000-lb 3S-2 vehicle, 30,000 lb or 37.5 percent over the legal gross weight, causes the same damage as three and one-third legal 80,000-lb 3S-2 vehicles. In all instances, increases in vehicle weight cause disproportionate increases in relative damage.

The data in Table 1 also illustrate a second relationship between weight and vehicle class. The relative equivalencies

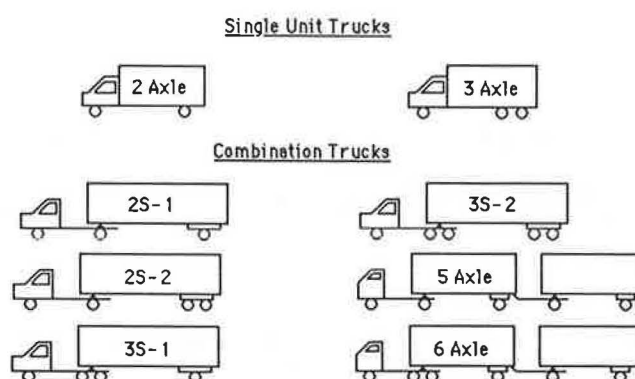


FIGURE 2 Vehicle classifications.

demonstrate that in addition to total weight relative damage is also associated with the number of axles on a vehicle. One 80,000-lb 2S-2 combination (four axles) causes the same damage as two 80,000-lb 3S-2 vehicles (five axles each). On the other hand, an 80,000-lb 3S-1-2 combination (six axles) causes the same damage as only 0.6 of an 80,000-lb 3S-2 combination. These two examples demonstrate quite clearly the relationship of damage to the number of axles on a vehicle. Increasing the number of axles on the vehicle reduces the overall stress associated with a given load.

A final damage factor, not given in Table 1 but derived from the AASHO Road Test, is the relationship between axle spacing and pavement stress. An equation known as the "bridge formula" that determines the maximum allowable gross weight of a vehicle based on the number and spacings between axles takes the following form:

$$W = 500 \times [LN/(N - 1) + 12N + 36]$$

where

- W = maximum weight in pounds that can be carried on a group of two or more axles to the nearest 500 lb,
- L = spacing in feet between the outer axles of any two or more consecutive axles, and
- N = number of axles being considered (8).

The logic of this equation is similar to that of a person's attempting to walk across ice that is too thin to support the person's weight; the person is likely to fall through. If the same person stretches out prone on the ice and squirms across, it is unlikely that the person would fall through (8). Application of the bridge formula is especially important in the design of bridges. A comparison of the stress effects of two 3S-2 vehicles of equal weight but different lengths is shown in Figure 3 (8). The bridge formula is a widely accepted principle that has been adopted by most states for determining gross vehicle weight limits.

Although the relative damage concept is widely accepted, the actual damages associated with overweight vehicles are not known, due primarily to the difficulty in determining the number and extent of illegal weight operations. Two approaches for estimating the costs of overweight vehicles in Texas are presented. The first is a scenario approach that was completed in a

TABLE 1 RELATIVE EQUIVALENCIES BY TRUCK TYPE (7)

Gross Vehicle Weight (lb)	Two-Axle	Three-Axle	2S-1	2S-2 ^a	3S-2	Five-Axle ^b	Six-Axle ^c
30,000	0.42	0.07	0.07	0.04			
40,000	1.22	0.26	0.32	0.11	0.05	0.05	0.03
50,000	2.83	0.79	0.81	0.32	0.13	0.11	0.08
60,000		1.66	1.69	0.74	0.30	0.28	0.17
70,000			3.11	1.23	0.60	0.51	0.33
80,000				2.01	1.00	0.94	0.59
90,000				3.23	1.69	1.60	0.95
100,000					2.50	2.37	1.49
110,000					3.39	3.39	2.16
120,000						4.67	3.05
130,000							4.08
140,000							5.10

NOTE: Relative equivalencies (1.00 for 80,000-lb 3S-2 combination) are for rigid pavement that distributes loads to the subgrade, having as one course a portland cement concrete slab of relatively high bending resistance.

^aThe 3S-1 combination has equivalencies nearly identical to the 2S-2 combination.

^bThe 2S-1-2 combination is the vehicle used for the five-axle category.

^cThe 3S-1-2 combination is used for the six-axle category.

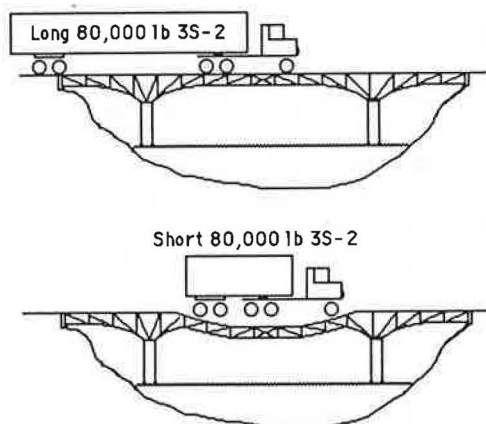


FIGURE 3 Truck length and bridge stress (8).

1983 study by The University of Texas at Austin Center for Transportation Research (CTR). The second approach is a new approach called the "revenue method."

CTR Scenario Approach

Utilizing 1980 Texas Truck Weight Survey data, two scenarios were simulated. The first scenario depicted the existing condition with respect to sizes and weights of vehicles operating on Texas highways. The second scenario represented a 100 percent compliance situation, that is, no overweight vehicles, accomplished by removing all overweight vehicles from the truck fleet and reassigning their payloads to an additional group of vehicles that could legally carry the payloads at maximum allowable weights. Equivalent axle loads (EALs) were then calculated and compared over a 20-year planning period.

The total EALs and their ratio calculated for the two scenarios are summarized in the following table (1):

	EALs (millions)		Ratio of EALs in Scenario 2 to Scenario 1
	Scenario 1	Scenario 2	
All highways	28.133	26.240	0.93

The results show that pavement damage for the 100 percent compliance situation is less than that for the existing condition, and that therefore pavement life is reduced by overweight vehicles. The financial costs associated with these changes were derived from a SDHPT computer program (REHAB) that forecasts pavement rehabilitation costs. Comparing the REHAB results from the two scenarios, \$9 million in pavement rehabilitation costs can be attributed to overweight vehicles in 1980, and \$125 million can be attributed over the 20-year design period (1).

The \$125 million represents a conservative amount. It does not include financial damages associated with bridge deterioration, which was beyond the scope of the CTR study because bridges are typically designed for a life of more than 20 years. The amount is also based on the Texas Truck Weight Survey, which underestimates the actual number of overweight violators. Finally, it excludes costs associated with enforcement and administration. Inclusion of these items would result in an additional \$135 million over the 20-year period (1).

Revenue Method

The cost to the state of overweight truck operations can be looked at in another way. Highway transportation financing is based on a user fee concept, that is, the users of the highway facilities pay for the construction, maintenance, and operation of the system. Accordingly, the more an operator uses the facilities, the more the operator pays for that privilege. The problem with overweight vehicles is that they do not contribute additional funds for the extra burden they place on the highway system. As noted earlier, overweight vehicles steal life from the roadways.

In 1980, highway users contributed nearly \$1.3 billion to the highway system through a variety of taxes and fees. Of this amount, heavy trucks (as shown in Figure 2) contributed \$402 million, or 31 percent. Applying 1980 vehicle registration numbers (375,830 heavy trucks), each heavy truck contributed an average of \$1,070 (9). This amount represents the amount that truck operators contribute based on legal weight limits. If a vehicle has operated at a capacity exceeding legal limits, it has deprived the state of additional revenues needed to maintain the system. An estimate of this amount can be calculated using the EAL relative damage concept. According to the CTR study, 24 percent of the weighed vehicles exceeded legal limits by an average of 8,000 lb (1). This amounts to 90,199 trucks (24 percent \times 375,830 registered trucks). Because the 3S-2 combination is the most common violator, more than 90 percent of the 1980 violations, it is used as the standard vehicle. Applying the equivalencies presented in Table 1, a 3S-2 combination overloaded by 8,000 lb has an equivalency factor of approximately 1.5. Therefore, because the overweight truck actually represents 1.5 trucks, each overweight truck should have paid an average of \$1,605, or \$535 more than what was actually paid. Based on the user fee approach, overweight vehicles deprived the state of Texas of \$48 million in 1980.

Regardless of how actual damages are calculated, overweight vehicles contribute to a faster deterioration of the highways. This faster deterioration is documented in the examination of State Highway Fund (SHF) disbursements. In 1980, construction of highway facilities represented 76 percent of total SHF expenditures, while in 1983 construction fell to 60 percent. In real dollars, there was a 26 percent decrease in highway construction. At the same time, maintenance costs of existing facilities increased 26 percent from 1980 to 1983 (2). Even more dramatic is the changing nature of the construction dollar. Review of the Texas SDHPT Operational Planning Document revealed that of the \$37.1 billion needed for construction over the 20-year planning period (1983–2002), 82 percent would be used for reconstruction of existing facilities (10). Combining this result with the effect of increasing weight loads found in the 1962 AASHO Road Test suggests that overweight vehicles cost the state of Texas many millions of dollars each year.

Economic Benefits for Overweight Operations

The benefit that a vehicle operator receives from overloading a vehicle is increased financial returns. Generally, truck operators are paid on an amount hauled basis. The more cargo that is transported, the more the hauler is paid. The profitability of overloading occurs because of the relationship between operating costs and vehicle weight. Using the 1980 Association of American Railroads Truck Cost Model and the 1979–1980 National Motor Transport Data Base, Gilckert and Paxson found that as cargo weight increases the operating cost per unit of weight decreases (11). The data in the following table display this relationship for the typical intercity trucker:

Cargo Weight (tons)	Line-Haul Cost Per Mile (¢)	Line-Haul Cost Per Ton-Mile (¢)
10	89.1	8.91
15	89.5	5.97
20	90.3	4.52
25	90.5	3.62

The table shows that although cargo weight increased by 150 percent, from 10 to 25 tons, the line-haul cost per ton-mile increased only 1.4 cents, or 1.6 percent. As a result, the line-haul cost per ton-mile declined 5.29 cents, or 59 percent (11).

The declining cost per ton-mile has a significant effect on trucker's profits. The more a truck is loaded, the greater the financial benefit. Table 2 gives the incremental economic incentives faced by a typical 3S-2 vehicle operator with a hauling rate of 5.6 cents/lb. Without consideration of any possible penalties, clearly, the operator has an incentive to load as much as possible on a vehicle.

The trucking industry as a whole can net considerable savings from illegal overweight operations. The 1983 CTR study estimated that overweight vehicles in Texas saved \$46.5 million in operating costs in 1980 (1). These savings are based on a comparison of the operating costs of the two scenarios discussed previously. The \$46.5 million in savings represents the hypothetical cost of reassigning illegal payloads to additional vehicles.

TABLE 2 INCREMENTAL INCENTIVE TO OVERLOAD IN TEXAS (12)

Cargo Weight (lb)	Income ^a (\$)	Operating Cost per Mile ^b (\$/mi)	Operating Cost per Trip ^c (\$)	Net Income (\$)	Incremental Incentive (\$)
25,000	1,400	78.9	395	1,005	0
40,000	2,240	86.2	431	1,809	804
55,000	3,080	94.5	473	2,607	1,602
70,000	3,920	104.0	520	3,400	2,395
85,000	4,760	114.6	573	4,187	3,182
115,000	6,440	139.0	695	5,745	4,740

^aIncome = 5.6¢ \times Cargo Weight.

^bThe operating cost per mile is based on research by Larkin.

^cOperating costs are based on a 500-mi trip.

ECONOMIC EFFECTS OF OVERWEIGHT FINE SCHEDULES

Statutory vehicle weight limits specify maximum loads for vehicles operating on roads and highways. As noted earlier, these limits are designed to protect the structural integrity of the highway system. Although most trucking operations comply with the weight laws, violators are a significant threat to a well maintained highway network. In addition, violators impose hardships on the trucking industry in the form of unfair competition. Illegally weighted trucks generate cost savings that allow the operator to offer rates lower than the legal competitor. The resulting abuse to the highway system, and disruption to the trucking industry indicate a need to evaluate weight enforcement programs.

An effective program for discouraging weight violations is contingent on two factors, the probability of being caught and the penalty. If operators see the penalties are less than the economic benefits of overloading, there is little incentive to comply with weight statutes. Moreover, any penalty is meaningless if operators perceive only a small likelihood of being weighed.

Existing Fines for Weight Violations

Current Texas law prohibits operation of vehicles in excess of 80,000 lb gross vehicle weight (GVW). In addition, limits are set for single axles (20,000 lb), tandem axles (34,000 lb), and other axle groupings according to a table based on the bridge formula. Vehicles that operate in excess of the prescribed limits without a special permit are cited to justice of the peace courts for persecution of a Class C misdemeanor. Actual fines and possible jail sentences vary according to the number of offenses. The following table lists the current range of fines and penalties for Texas (13):

Offense	Minimum Fine (\$)	Maximum Fine (\$)	Jail Sentence (max) (days)
First	100	150	0
Second	150	250	60
Third	200	500	182

The penalties for the second and third offenses are imposed only if they occur within 1 year of the prior offense. These penalties became effective in September of 1983, with penalties before this period ranging from \$25 to \$200. Table 3 gives

TABLE 3 TEXAS OVERWEIGHT FINE COLLECTIONS FOR 1981-1984

Year	Overweight Fines (\$)	
	Total	Average
1981	1,743,237	41.37
1982	2,072,193	43.45
1983	2,505,175	53.47
1984	3,989,190	102.52

SOURCE: Texas Department of Public Safety, unpublished data.

the total and average fines collected over the last 4 years. The significant increase in the average fine in 1984 is reflective of the higher minimum fine (\$100) and not an increase in overweight violations. Actual violations decreased by 17 percent, perhaps a reflection of the higher penalties for violators.

Unlike Texas, most states attempt to discourage overweight trucking by imposing fines based on the amount of weight in excess of legal weights. Generally, as the weight increases so does the fine. In all, 40 states had fine structures reflecting the amount of excess weight (14). The four states surrounding Texas are a good sample of the types of fine schedules used by various states.

New Mexico and Oklahoma impose a specific fine depending on how much the vehicle is overweight. Table 4 presents

TABLE 4 OKLAHOMA AND NEW MEXICO FINE SCHEDULES (15)

Amount Overweight (lb)	Fines (\$) by State	
	Oklahoma	New Mexico
700-2,000	80	25 ^a
2,001-3,000	130	25 ^a
3,001-4,000	180	40
4,001-5,000	230	75
5,001-6,000	280	125
6,001-7,000	330	200
7,001-8,000	380	275
8,001-9,000	430	350
9,001-10,000	480	425
10,001 +	500	500

^aThe first overweight category for New Mexico is 1,000 to 3,000 lb.

the fine schedules for these two states. New Mexico's fines range from \$25 to \$500 whereas Oklahoma's fines range from \$80 to \$500. Both of the states allow some tolerance for overweight vehicles, 700 lb for Oklahoma and 1,000 lb for New Mexico.

Louisiana also operates its fine structure on a graduated scale, that is, the fine increases as the amount of excess weight increases. However, instead of assessing a specific fine for each weight grouping, a cents-per-pound fine is charged. The Louisiana schedule, as shown in the following table, ensures that violators not only receive a higher fine per pound overweight but also are charged at a higher rate (16).

Amount Overweight (lb)	Fine (¢/lb)	
	Over Gross Weight	Over Axle Weight
0-3,000	2	1
3,001-5,000	3	1.5
5,001-10,000	4	2
10,001 +	5	5

A flat fine of \$100 is added for overweights in excess of 10,001 lb. If vehicle exceeds gross weight but not axle weight, the "over gross weight" schedule is used. If vehicle exceeds axle weight but not gross weight, the "over axle weight" schedule is used. When two or more axles are overweight, these fines are figured separately and added together. If vehicle

exceeds both gross and axle weight, fines are figured for both schedules and the larger of the two penalties is imposed. This approach attempts to offset the economic incentives for increasing vehicle loads. In addition, a cents-per-pound approach does not limit the maximum penalty as do the Oklahoma and New Mexico schedules. This is an important factor when considering excessive legal weight violations. [In Texas, nearly 10 percent of all violators exceed weight limits by 20,000 lb or more (4).]

Arkansas combines a fine structure similar to Louisiana with a penalty based on the operator's number of offenses. In addition to the fines imposed according to the following table, overweight violators are charged by the Arkansas motor vehicle laws a maximum of \$100 for the first offense, \$200 for the second offense within 1 year of the first, and \$500 for third and successive offenses within 1 year of a previous offense.

Amount Overweight (lb)	Fine (max) (\$/lb)
0-1,000	2
1,001-2,000	3
2,001-3,000	4
3,001 +	5

For overweights of 0-1,000 lb a minimum fine of \$10 is imposed. If an operator is found to have willfully avoided being weighed at a weigh station, the penalty is doubled. This type of arrangement punishes the recurrent violator as well as the excessive offender.

Economic Effects of Penalties

Truck operators have an incentive to overload their vehicles. A vehicle's payload increases much more rapidly than do the corresponding operating costs. In order to offset this incentive, states have imposed fines to serve as an economic disincentive. On the surface, the various types of fine schedules appear to incorporate an increasing economic disincentive that offsets the

incremental benefits to overloading. However, as shown by the data in Table 5, this result is not necessarily the case.

The different weight scenarios in Table 6 are for a first-time GVW offense charged at a maximum allowable rate. Because of its flat fee approach, Texas represents the worst-case scenario. A trucker in Texas who decides to overload can minimize the cost associated with the fine by maximizing the load. To a less extent, a similar problem persists in Oklahoma and New Mexico. The overall fines increase with weight, but the costs associated with each pound of weight decline at certain points in the schedule. Thus, overweight operators in all three states can minimize the effects of the fine by increasing their loads. The Arkansas schedule, which appears as the most excessive of the listed fine schedules, also has a problem with a declining fine per pound overweight. Clearly, if a vehicle operator makes a conscious decision to overload, the fine schedules provide an incentive, not a disincentive, to maximize the overload.

The economic incentive problem for the various schedules occurs when a flat rate fine is introduced. The decline in the cents-per-pound charge in the Arkansas case is a result of the \$100 fine charged all first offenders. In Louisiana, the decline occurs when the \$100 is added to all weight in excess of 10,000 lb. For New Mexico, it is a result of the \$500 flat rate for all weights above 10,000 lb. The Oklahoma schedule suffers from the same problem, as well as from a poor selection of fines for the various weight groupings.

Applying these various fine schedules with the incremental incentives to overload (Table 2) demonstrates the potential effects of fines. Table 7 gives the overall incremental incentive to overload for a typical 3S-2 vehicle on a 500-mi trip. The Arkansas schedule provides a disincentive for violators as long as their gross weight is below 120,000 lb; for more than 120,000 lb, the venture becomes profitable again. The Louisiana schedule allows for an incentive up to 90,000 GVW and for more than 120,000 lb GVW. Between these two amounts there is a declining economic disincentive. The schedules of the remaining three states do not offset the economic benefits of overloading.

TABLE 5 OVERWEIGHT FINES FOR FIRST OFFENSES

Amount over Gross Weight (lb)	Arkansas (\$)	Louisiana (\$)	New Mexico (\$)	Oklahoma (\$)	Texas (\$)
2,000	160	40	25	80	150
6,500	425	260	200	330	150
10,000	600	400	425	480	150
15,000	850	850	500	500	150
30,000	1,600	1,600	500	500	150

TABLE 6 OVERWEIGHT FINES PER POUND FOR FIRST OFFENSES

Amount over Gross Weight (lb)	Arkansas (\$)	Louisiana (\$)	New Mexico (\$)	Oklahoma (\$)	Texas (\$)
2,000	8.0	2.0	1.3	4.0	7.5
6,500	6.5	4.0	3.1	5.1	2.3
10,000	6.0	4.0	4.3	4.8	1.5
15,000	5.7	5.7	3.3	3.3	1.0
30,000	5.3	5.3	1.7	1.7	0.5

TABLE 7 INCREMENTAL INCENTIVES TO OVERLOAD, VARIOUS STATES

Vehicle Weight (lb)	Incremental Incentive (\$)	Potential Fine (\$)	Overall Incremental Incentive (\$)
Arkansas			
80,000	0	0	0
85,000	265	350	-85
90,000	529	600	-71
95,000	793	850	-57
100,000	1,056	1,100	-44
110,000	1,580	1,600	-20
130,000	2,621	2,600	+21
Louisiana			
80,000	0	0	0
85,000	265	150	+115
90,000	529	400	+129
95,000	793	850	-57
100,000	1,056	1,100	-44
110,000	1,580	1,600	-20
130,000	2,621	2,600	+21
New Mexico			
80,000	0	0	0
85,000	265	75	+190
90,000	529	425	+104
95,000	793	500	+293
100,000	1,056	500	+556
110,000	1,580	500	+1,080
130,000	2,621	500	+2,121
Oklahoma			
80,000	0	0	0
85,000	265	230	+35
90,000	529	480	+49
95,000	793	500	+293
100,000	1,056	500	+556
110,000	1,580	500	+1,080
130,000	2,621	500	+2,121
Texas			
80,000	0	0	0
85,000	265	150	+115
90,000	529	150	+379
95,000	793	150	+643
100,000	1,056	150	+906
110,000	1,580	150	+1,430
130,000	2,621	150	+2,471

Probability of Apprehension

Until now, it has been assumed in the economic incentive calculations that violators will be apprehended. In practice, this does not happen and therefore expected fines are significantly less than potential fines. For example, if the probability of being weighed by a state weight enforcement agency is 10 percent and the probability of paying a \$200 fine for being overweight is 50 percent, the expected fine is only \$10. [$\$200 \text{ (fine)} \times 0.10 \text{ (probability of being caught)} \times 0.50 \text{ (probability of being required to pay the fine)} = \10 .] Knowing the probability of apprehension is, therefore, very important in developing a fine schedule. Estimating this figure is difficult, however, because the figure is dependent not only on the actual level of

enforcement but the vehicle operator's perceptions. Glickert and Paxson interviewed officials from three states and asked them to give an estimate assuming the trucker was using avoidance measures. The officials' estimates ranged from a low of 5 percent in Tennessee to a high of 20 percent in Indiana, with 15 percent for Iowa (17).

The probability of apprehension in Texas is lower than that in most other states because of the number of highway miles that must be patrolled. The following table gives the number of vehicles that are checked and weighed each year by Department of Public Safety (DPS) license and weight officers:

Year	No. Vehicles Checked	No. Vehicles Weighed	Vehicles Checked That Are Weighed (%)
1981	616,091	208,270	33.8
1982	675,356	228,922	33.9
1983	633,409	213,408	33.7
1984	644,662	219,766	34.1

According to the DPS, license and weight inspectors check vehicles about every 12,500 mi, based on an estimated 7.8 billion miles of truck travel and checking by the Texas DPS of at least 625,000 trucks a year. Using this figure, it is possible to estimate the probability of apprehension based on the length of a trip. These probabilities are given in Table 8. The overweight

TABLE 8 PROBABILITY OF APPREHENSION BASED ON TRIP LENGTH

Trip Length (mi)	Chance of Being Checked (%)	Chance of Being Weighed (%)
50	0.4	0.1
100	0.8	0.3
250	2.0	0.7
500	4.0	1.4
800	6.4	2.2
1,100	8.8	3.0
1,500	12.0	4.1

violator's chance of being apprehended is further reduced because every vehicle checked is not weighed. According to the DPS, during 1981-1984 about 34 percent of all vehicles checked were weighed.

It is possible to present a more realistic picture of the incremental incentives to overload. Table 9 shows recalculated incentives for a 500-mi trip based on effective fines for Arkansas, the state with the highest penalties, and Texas, the state with the lowest. Because of their enforcement activity, a 20-percent probability is used for Arkansas. A 4-percent probability is used for Texas to compensate for the fact that the DPS vehicle checks include vehicles that are not heavy trucks. Therefore, the percentage chance of a heavy truck's being weighed would be higher than 34 percent. A 4-percent apprehension rate reflects a situation where all heavy trucks, as identified in Figure 2, are weighed. The results present a disturbing picture. Despite efforts of law enforcement officials and the designers of the various fine schedules, current weight statutes have little effect on the economic decisions of overweight violators.

TABLE 9 ADJUSTED INCREMENTAL INCENTIVES TO OVERLOAD

Vehicle Weight (lb)	Incremental Incentive (\$)	Effective Fine ^a (\$)	Adjusted Incremental Incentive (\$)
Arkansas			
80,000	0	0	+0
85,000	265	70	+195
90,000	529	120	+409
95,000	793	170	+623
100,000	1,056	220	+836
110,000	1,580	320	+1,260
130,000	2,621	520	+2,101
Texas			
80,000	0	0	+0
85,000	265	6	+259
90,000	529	6	+523
95,000	793	6	+787
100,000	1,056	6	+1,050
110,000	1,580	6	+1,574
130,000	2,621	6	+2,615

^aEffective Fine = Potential Fine × Probability of Apprehension.

A Fine Schedule for Texas

There are three important considerations in the design of an overweight fine schedule. First, the schedule should establish large enough disincentives to offset any incentives for overloading vehicles. Second, the fines should recover damages that have been inflicted on the highway system. And, third, the fines should recover an adequate portion of the administrative costs associated with enforcement. Because of the significance of the incremental benefits to overloading, the disincentive is the key variable in the fine schedule.

A review of the schedules of the states surrounding Texas provide useful information for developing an effective schedule. The schedule should have a graduated scale, that is, the amount of the fine should increase as the weight increases. The schedule should also use a cents-per-pound basis and not a flat fee amount to avoid fluctuations that occurred in the Louisiana schedule (see Table 5). Table 10 provides a fine schedule for Texas based on an effective rate that offsets the incremental incentives to overload.

TABLE 10 ALTERNATIVE FINE SCHEDULE FOR TEXAS

Amount Overweight (lb)	Fine (¢/lb)
0–2,000	5.0
2,001–5,000	5.5
5,001–8,000	6.0
8,001–12,000	6.5
12,001–18,000	7.0
18,001–25,000	7.5
25,001 +	9.0

The discussion of the relative damage concept by AASHTO EALs revealed that damage is directly related to axle weights. Therefore, if a fine schedule is to recover highway damages,

the fine schedule should focus on axle weight violations (single, tandem, and axle grouping according to the bridge formula). The schedule in Table 11 is an adaptation of that in

TABLE 11 ALTERNATIVE FINE SCHEDULE FOR TEXAS ADJUSTED FOR GVW AND AXLE WEIGHT

Amount Overweight (lb)	Fine (¢/lb)	
	Over GVW	Over Axle Weight
0–2,000	2.0	3.0
2,001–5,000	3.0	4.0
5,001–8,000	4.5	6.0
8,001–12,000	6.0	8.0
12,001–18,000	7.5	10.0
18,001–25,000	9.0	12.0
25,001 +	11.0	15.0

Table 10 but with an emphasis on axle weight violations. The difference in the fines for vehicles over their legal GVW and legal axle weight reduces some of the disparity with regard to relative pavement damage. (As noted previously in Table 1, a two-axle vehicle with a GVW of 40,000 lb does more damage than a six-axle vehicle weighing 90,000 lb.) Because pavement damage is related to the magnitude and repetition of axle loads, this fine schedule penalizes vehicles more heavily for exceeding their axle weights than for exceeding their GVWs. It is important to note, however, that this fine schedule does not eliminate the disparity between axle weight and GVW calculations and is not a pure damage-based schedule. A pure damage-based schedule approach would require separate fine schedules for each type of vehicle. Because the key element of the fine schedule is economic disincentive, this type of approach is unnecessary.

Unlike the Louisiana schedule, fines for vehicles whose weight exceeds both the legal GVW and legal axle weights are cumulative in this schedule. For example, if a 3S-2 combination has a GVW of 90,000 lb with 6,000 lb over maximum on one tandem axle and 4,000 lb over maximum on the other tandem axle, the fine is calculated as follows:

Total fine	=	GVW fine + axle weight fine	
GVW fine	=	10,000 × 6¢	= \$ 600
Axle weight fine	=	(6,000 + 4,000) × 8¢	= \$ 800
Total fine	=	\$600 + \$800	= \$1,400

The real test for the fine schedule in Table 11 is to determine if it offsets the incremental incentives to overload. Using the examples cited previously, the Texas incremental incentive to overload using the new fine schedule is presented in Table 12. The schedule has an increasing economic disincentive built into it. A potential violator pays a stiff penalty for increasing cargo weight beyond tolerable limits.

The current fine schedules for overweight violations in Texas and many other states are wholly inadequate. By their structure, they encourage rather than discourage overweight violations. If a schedule similar to the one presented in Table 12 were operational, the number of overweight violations would decrease. Truck operators are aware of the penalties associated with illegal operations. The DPS, for example, reported that

TABLE 12 INCREMENTAL INCENTIVE TO OVERLOAD IN TEXAS BASED ON THE NEW FINE SCHEDULE

Vehicle Weight (lb)	Incremental Incentive (\$)	Fine (\$)	Adjusted Incremental Incentive (\$)
Arkansas			
80,000	0	0	0
85,000	265	350	-85
90,000	529	1,400	-871
95,000	793	2,625	-1,832
100,000	1,056	4,200	-3,144
110,000	1,580	7,800	-6,220
130,000	2,621	13,000	-10,379

because of the increased fines in 1983 (a \$75 increase in the minimum fine) and new Texas legislation on aiding and abetting, there was a 12 percent reduction in overweight violations (18). If Texas is to maintain the integrity of its highway system, a further increase in its fine schedule is required.

CONCLUSIONS

Overweight trucking has serious economic consequences for the Texas highway system, costing between \$6 and \$48 million a year. Although road deterioration dominates the overweight vehicle debate, other issues are also important in the design of weight laws. In addition to protecting the roadway, vehicle weight limits promote public safety and reduce undue traffic delays for motorists. Heavy truck accidents account for a large share of all traffic accident losses. One highway fatality in nine occurs in accidents involving heavy trucks, even though heavy trucks represent only about 3 percent of the vehicles on Texas highways (19, 20). Although conclusive statistics are not available regarding the impact of vehicles on highway safety, public safety is an important consideration in the design and enforcement of weight statutes.

Overweight operations can also adversely affect a state's economy through unfair competition. Illegal trucking results in considerable cost savings for the vehicle operator that can be passed on in the form of lower freight rates that enable the illegal trucker to enjoy an unfair advantage over competing legal vehicles. Overweight vehicles may also affect other modes of transportation. A recent U.S. Department of Transportation study suggests that large-scale evasions of weight limits could result in some shifting of freight from rail to truck (21).

The economics of overloading have had significant implications for the state highway system and the trucking industry. The dynamics of vehicle operating costs have provided truck operators with strong incentives to increase their payloads. Consequently, some operators have chosen to load their vehicle at a weight higher than what the highway facility was designed to bear. The result, expensive and rapid deterioration of the state roadways, has forced reevaluation of weight enforcement programs. The first step in these programs is the development of fine schedules that reduce the incentives to overload vehicles.

REFERENCES

1. C. M. Walton and C.-P. Yu. *An Assessment of the Enforcement of Truck Size and Weight Limitations in Texas*. Center for Transportation Research, University of Texas at Austin, April 1983.
2. *Texas Transportation Finance Facts 1984*. Texas State Department of Highways and Public Transportation, Austin, 1984.
3. *Operational Planning Document Study*. Texas State Department of Highways and Public Transportation, Austin, July 1982.
4. *Texas Truck Weight Survey*. Texas State Department of Highways and Public Transportation, Austin, 1984. (Computer printout).
5. *Special Report 61E: The AASHO Road Test*. HRB, National Research Council, Washington, D.C., 1962.
6. *Report to the Congress, Excessive Truck Weight: An Expensive Burden We Can No Longer Support*. The Comptroller General, U.S. General Accounting Office, July 1979.
7. K. J. Cervenka. *Characterization of the Standard Vehicle*. Center for Transportation Research, University of Texas at Austin, Sept. 10, 1984.
8. *Bridge Gross Weight Formula*. FHWA, U.S. Department of Transportation, April 1984.
9. A. Garcia-Diaz, A. Villarreal, D. Burke, C. M. Walton, M. A. Euritt, and K. J. Cervenka. *Texas Highway Cost Allocation*. Texas Transportation Institute, Texas A&M University System and Center for Transportation Research, University of Texas at Austin, Nov. 1985.
10. C. M. Walton, L. B. Boske, W. N. Grubb, K. J. Cervenka, and M. A. Euritt. *The Texas Highway Cost Index: An Assessment*. Policy Research Institute, University of Texas at Austin, Aug. 1984.
11. J. P. Gilckert and D. S. Paxson. The Value of Overweighting to Inter-city Truckers. Presented at the 60th Annual Meeting of the Transportation Research Board, Washington, D.C., Jan. 15, 1981.
12. J. G. Larkin. *Modeling Future Truck Weight Patterns as Influenced by Alternative Vehicle Weight Legislation*. Master's thesis. University of Texas at Austin, 1978.
13. *Motor Vehicles—Weight Limitations—Enforcement—Penalties*. Chapter 837, §R, 1983. Gen. Tex. Laws 4764.
14. T. Griebel. *Report on Enforcement Against Overweight Trucks*. Office of the Governor of Texas, Jan. 15, 1984.
15. *Overweight Vehicles—Penalties and Permits: An Inventory of State Practices*. FHWA, U.S. Department of Transportation, Nov. 1982.
16. *Louisiana Regulations for Trucks, Vehicles, and Loads, 1983*. Louisiana Department of Transportation and Development.
17. *NCHRP Synthesis 68: Motor Vehicle Size and Weight Regulations, Enforcement, and Permit Operations*. TRB, National Research Council, Washington, D.C., April 1980.
18. *Aspects of Overweight Vehicle Operations in Texas*. Center for Transportation Research, University of Texas at Austin, and Texas Transportation Institute, Texas A&M University System, and Texas State Department of Highways and Public Transportation, Aug. 23, 1984.
19. *Highway Statistics 1981*. FHWA, U.S. Department of Transportation, 1981.
20. *1982 Census of Transportation Truck Inventory and Use Survey—Texas*. Bureau of the Census, U.S. Department of Commerce, Aug. 1981.
21. *Overweight Trucks—The Violation Adjudication Process: Umbrella of Compliance*. FHWA, U.S. Department of Transportation, July 1985.

Publication of this paper sponsored by Committee on Application of Economic Analysis to Transportation Problems.