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ANNUAL LICENSE FEES AND OTHER CHARGES FOR ROAD TRANSPORTATION OF HAZARDOUS MATERIALS

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ABSTRACT

In September 1992 the United States Department of Transportation imposed a $300 annual fee on motor carriers of certain kinds of hazardous materials. The revenue raised will be used to pay for training emergency response personnel. Econometric analysis suggests that accident risk varies significantly depending on the size and type of carrier, and the particular hazardous commodity hauled. An improved system of licenses and other charges which takes these factors into account in determining what should be paid by individual carriers would provide greater incentives for safe operation.

INTRODUCTION

The Hazardous Materials Transportation Uniform Safety Act of 1990 (HMTUSA) gave the United States Department of Transportation (DOT) broad powers to set fees for transporting hazardous materials based on the type of material, the level of "threat to property, persons, and the environment," and the proportion of a firm's business that involves the transportation of hazardous materials. However, in September 1992 the DOT chose to set a fixed fee of $300 for firms that transport: radioactive materials, over 25 kilograms of class A or B explosives, packages of more than one liter of substances that are extremely toxic by inhalation, and bulk or large packaged shipments emanating from one shipper.

The main purpose of this paper is to evaluate this fee system and propose changes in it that would more faithfully carry out the intent of HMTUSA in the mandate that was given to DOT by Congress. The paper is divided into three parts. The first contains a brief theoretical statement on what economists would view as an optimal system of fees for the transport of hazardous materials. It examines the various costs associated with a hazardous materials accident.

Part two of the paper uses multivariate regression analysis to show that accident rates vary significantly depending on the characteristics of firms and the specific commodity carried.

Part three proposes a fee structure that the authors believe would be an improvement over the present flat fee system. The preferred structure employs a

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differential annual fee based on past accident experience of different kinds of firms and the materials they transport, a user charge that covers the variable cost of cleaning up a particular spill, and a charge for environmental damage.

1. THE COSTS OF HAZARDOUS MATERIALS ACCIDENTS

In an ideal world trucking firms would have to bear all of the costs of an incident for which they are at fault, some directly and some indirectly. Firms would then be able to make informed tradeoffs between the costs of investments that prevent accidents, such as improved driver training and high standards of vehicle maintenance, and the full costs of accidents. With such internalization of accident costs the optimal, that is to say economically efficient, number of accidents would occur. Economists would argue that the reason there may currently be an excessively large number of accidents and a "truck safety problem" is that carriers do not have to bear all of the costs associated with accidents. We turn now to a review of these costs.

The costs of truck accidents fall into four broad categories. The first of these costs are internal to the firm. They entail such things as: the cost of repairing or replacing vehicles; health benefits for drivers or death benefits to drivers' families; restitution to shippers for damage to or loss of cargo; and loss of goodwill and a decline in revenue because shippers are knowledgeable about the quality of service offered by different firms and are likely to avoid those that have many accidents. If a motor carrier is involved in an accident that is caused by another party, the costs of the accident should be recovered from that party and/or its insurance company. If the trucking firm is at fault and cannot recover costs from another party, then these costs are internalized by the motor carrier. They are internal even when they are covered by the trucking firm's own insurance because firms that have a high accident rate find that their insurance premiums or the amount of money that they must put into a private fund increases. The trucking firm has every incentive to invest in safety up to a point where its private marginal cost of achieving safety is just equal to the marginal benefit it derives from such investments. This being the case there is no need to include these costs in a government imposed system of license fees and user charges.

The second category of costs involves identifiable individuals who are not shippers or carriers. They are third-party individuals and organizations, such as other road users and owners of property adjacent to highways, who may be injured in an accident or have their property damaged. At present there is also no need to include these costs in a system of government fees and user charges. Injured individuals can recover damages through legal torts from parties at fault. Although the tort system is not perfect, motor carriers have a strong incentive to take the accident awards and litigation costs into account when designing safety investment programs. Even if settlements are covered by insurance, carriers have an incentive to keep insurance premiums to a minimum.

The third category of costs is quite similar to that we have just described, but in this case the damage is to the environment and broad groups of individuals. Rivers may become polluted, fish and other wildlife may be killed, and valuable plants and

trees destroyed. The air and groundwater may become polluted. Some of the cleanup costs, such as hiring contractors to remove contaminated soil and debris and taking it to waste depositories, may be recovered directly from motor carriers or other at-fault parties, or litigation can be instigated citing the provisions of such laws as the Clean Water Act of 1977 or the Resource Conservation and Recovery Act of 1976. However, courts may be unwilling to make awards to parties too far removed from an accident site, and it is often the case that cleanup costs are borne by public agencies. Other costs may be difficult to quantify, may affect many unidentified victims, or may be difficult to substantiate in a legal action. A large number of individuals in an affected area may have to be evacuated and spend days away from home at some expense to themselves. Businesses in the vicinity may suffer temporarily reduced revenues. An accident may also require that all traffic in the vicinity of the accident be delayed and/or rerouted to an alternative, longer route. To ensure that firms have the correct incentives to provide safe operation, the full societal and environmental costs should be recovered from parties at fault.

The final category of costs that result from an accident are associated with the response of public agencies such as fire department personnel who are the first responders, police officers who control traffic at the scene of an accident and assist in the evacuation of people in the immediate area, and the provision of publicly provided emergency medical service. Most of these costs are different from those described above. The first three categories of costs are only incurred when an accident occurs. If there is no accident then there are no costs. In contrast, many of the public costs of emergency response exist whether or not there are accidents. In a sense they are fixed costs.

It might be argued that fire and police service is normally provided, and that there is therefore no need to burden trucking firms with additional fees since they already pay local property taxes at their bases of operation. However, there are identifiable additional costs for fire and police departments if they are to respond adequately to hazardous materials truck accidents.

Many serious truck accidents occur on the open road away from urban areas. Unlike fire departments of large urban areas that have experience in dealing with chemical and other industrial fires and accidents, few rural fire and police departments have such experience. They are accustomed to dealing with domestic and agricultural fires, and routine road accidents. They are often staffed by volunteers. There are identifiable additional costs that such departments will incur if they have to respond to spills of hazardous materials, accidents that produce emissions of poisonous gases, etc.

Rural fire and police personnel will have to receive special training if they are to recognize and deal with the specific hazards that particular commodities pose. The emergency response guides published by the United States and Canadian governments indicate the necessity for training of response personnel. These training costs are of a recurrent nature since first responders must be continually updated on the new hazardous and toxic materials being developed by industry, and new and improved methods of dealing with them. It is the purpose of the license fee to allow grants to be made by the federal government to allow training and response planning by local authorities.

There are also costs involved in upgrading the equipment owned by local fire and police departments. Responding to hazardous materials truck accidents clearly involves the use of equipment that is unnecessary for dealing with domestic fires and routine highway accidents. Some hazardous commodities require standards of protective clothing higher than those normally used by fire departments. There may also be the need for lime, soda ash, and dry chemicals to be held in stock as extinguishing agents. It may no longer be possible to rely as fully on volunteers as in the past. Rural fire departments may have to hire some number of professionally trained, full-time staff. Economists normally view labor as a variable cost. However, that is not the case here. The cost of full-time labor will be incurred when the personnel are standing ready to respond to an accident as well as when they are actually coping with one. HMTUSA does not have any provision for using license fees to provide funding to local authorities to purchase specialized equipment or expand numbers of staff.

In an ideal world the costs of emergency response would be passed on to parties that cause hazardous materials accidents, be they motor carriers or other road users. Any variable costs incurred in the response of emergency services, such as overtime payments, attendance fees for volunteer departments, or the use of extinguishing materials, should be billed directly to the trucking firm if that firm is at fault. The bill should be sent to the other road user if that user causes an accident involving a truck carrying hazardous materials.

The recurrent cost of additional equipment and training needs to be paid from a central fund. Some fraction of this fund should be raised from the trucking industry in the form of an annual license fee. The proportion paid by the industry should be related to the proportion of accidents in which a truck rather than another road user is at fault. The balance of the fund should be derived from other road users by use of general tax revenues, a supplement on annual automobile registration fees, or a tax on insurance premiums. For the fraction of the fund raised from the trucking industry, a rational system should have the annual license fee paid by individual carriers be proportional to the actuarial risk posed by that type of carrier and the commodity carried. If there is evidence that accident rates vary according to different classes of carriers and the commodities they haul, then the flat $300 fee proposed by DOT is inappropriate. The next section of the paper investigates the evidence for differential risk.

2. EVIDENCE ON DIFFERENTIAL RISK

Accident Risk of Hazardous Material Carriers

In an earlier paper, the authors presented an analysis of the characteristics of carriers of hazardous materials and their accident performance (Moses and Savage, 1992). The data used in the investigation were derived from initial "Safety Review" audits of U.S. interstate motor carriers. These audits are mandated by the 1984 Motor Carrier Safety Act. In the course of these audits, data are collected on firms' physical characteristics, types of goods carried, accident record, and compliance with federal

motor carrier safety regulations. We obtained the entire database of firms that were audited between October 1986 and November 1991. When cleaned up, the dataset contained 75,577 firms of which 13,498 (18%) indicated that they carried hazardous materials.

Using Poisson regression techniques, we were able to determine that carriers of hazardous materials had a higher accident rate than those that did not transport these goods. Firms that carried hazardous materials exclusively had an accident rate 11% higher than comparable firms that did not carry these commodities; they had a rate of fatalities and serious injuries that was 22% higher. Firms that carried hazardous materials as well as general freight had an accident rate that was 18% higher, and a fatality and injury rate that was 24% higher, than the rates of two kinds of firms: (1) those that do not carry general freight or hazardous materials, and (2) firms that carry one of the above but not the other.

When this information on accident frequency is combined with the knowledge that hazardous materials accidents require specialized firefighting training and equipment, it is clear why hazardous materials carriers should pay a supplemental annual license fee. They require more emergency response facilities and call on them relatively more frequently than other carriers.

Accident Risk of Different Types of Carriers and Hazardous Materials

We now turn our attention to the 13,498 firms that indicated they carried hazardous materials. A multiple regression model is used to explain the effect on accident rates of firm size, other characteristics, and the specific hazardous materials hauled. This information is used as a basis of a proposed license fee system that improves on the one that DOT has adopted.

Poisson regression techniques are employed to explain two measures of accident occurrence. One is the number of "reportable accidents" that a firm experienced in the 365 days prior to the audit. Reportable accidents are defined as accidents involving a fatality, an injury, or more than approximately $5,000 in property damage. Many accidents that involve small amounts of damage are not included in this database. The second measure of accident occurrence is the number of fatalities and serious injuries associated with the above mentioned accidents. The latter represents a measure of the severity of the accidents. Explanatory variables were firm size measured by annual fleet miles, the percentage of drivers involved in trips over 100 miles, a dummy variable for private carriage, a dummy variable representing an unsatisfactory audit rating, and dummy variables for different categories of hazardous materials. The appendix to the paper describes the Poisson regression technique and gives more details on the variables employed.

Before describing the results, there are some data problems that must be explained. The first is that data do not exist on the amount or proportion of a firm's business that each hazardous material represents. Firms do, as part of the audit, complete a "census" form where they identify which of 25 categories of non-hazardous goods and 21 sub-categories of hazardous goods they carry. They also indicate whether

the hazardous material is carried in tanks or packages or both. They can classify themselves in as many categories as they wish. The data only permit the determination of whether a particular hazardous material is carried or not.

The second problem is that firms routinely carry several of the 21 categories of hazardous materials, and often do so in both tanks and packages. Thus any econometric analysis that used dummy variables for all possible categories of hazardous material and type of packaging would run into a severe problem of collinearity. We decided to consolidate the potential 42 categories, 21 hazardous materials and 2 kinds of packaging, into 9 categories. A correlation table was used to decide the aggregations. After the consolidations were carried out, we found that on average firms carried 1.6 of the 9 categories. The 9 categories are: explosives, liquids in tanks, liquids in packages, gases in tanks, gases in packages, poisons, radioactive materials, hazardous wastes, and an "other" category.

The regression results are shown in table 1. The coefficients are interpreted under two headings: firm characteristics and the commodity carried.

Firm Characteristics. Accident rates decline with firm size. The coefficient on total fleet miles has a value significantly less than unity in both of the regressions. This result means that accidents increase less than proportionately with miles, i.e., the rate of accidents declines with size. In practical terms, accident rates of firms that travel 1 million miles a year are 23% below those of very small firms, i.e., those that operate 5,000 miles per annum. Firms with annual mileages of 5 million have accident rates 27% below those of the very smallest firms. Fatality and injury rates decline more slowly with size. Firms with annual mileage of 5 million have fatality and injury rates about 17% below those of the very smallest firms.

Long-distance operations are associated with higher accident rates. Long-distance operators are defined as firms whose drivers are all involved in trips that exceed 100 miles. They have a total accident rate that is 22% higher than firms that are exclusively involved in short-distance operations, and a rate of fatalities and injuries that is 53% higher. This result is not surprising. The measures of accidents used in this analysis exclude the minor damage-only incidents that frequently occur in congested urban areas. Higher speeds that occur on the open road result in accidents that are more serious in terms of fatalities, serious injuries, and property damage. This result reinforces our earlier comment that emergency response training is particularly needed by fire and police departments in rural areas.

Private carriers appear to have accident rates that are about 30% lower than those of comparable for-hire carriers. This is true for both reportable accidents, and fatalities and injuries.

Firms that are rated unsatisfactory in government safety audits have reportable accident rates that are 50% higher than firms rated conditional or satisfactory, though these accidents do not result in a higher incidence of fatalities and injuries.

These findings are particularly pertinent, given that different types of hazardous materials are hauled by different kinds of trucking firms. In table 2 a comparison is made of the leading characteristics of the firms that haul the various hazardous materials. There are a number of notable features. The first is that radioactive materials,

Table 1: Multiple Regression Analysis of Hazardous Materials Carriers

Dependent variable	Reportable Accidents	Fatalities & Injuries
Audit Dates	All Audits	Before 11/1/90
Observations	13,498	11,732
Proportion of Variation Explained	0.86	0.74
Log-Likelihood	- 11,659	- 9,547
Log-likelihood (log of miles and constant)	- 11,904	- 9,790
Explanatory variables (with t statistics in parentheses)		
Constant	-13.680 (169.65)	-14.393 (142.97)
Log of Total Fleet Miles+	0.954 (9.00)	0.973 (4.20)
Percent of Drivers Employed on Trips over 100 Miles	0.204 (7.37)	0.423 (11.71)
Dummy Variable - Private Carrier	- 0.294 (12.07)	- 0.409 (13.16)
Dummy Variable - Explosives	0.015 (0.65)	0.011 (0.37)
Dummy Variable - Liquids in Tanks	0.071 (2.94)	0.086 (2.92)
Dummy Variable - Liquids in Packages	- 0.019 (0.77)	- 0.015 (0.48)
Dummy Variable - Gases in Tanks	- 0.169 (4.23)	- 0.038 (0.81)
Dummy Variable - Gases in Packages	0.115 (5.54)	0.099 (3.95)
Dummy Variable - Poisons	0.025 (1.07)	- 0.002 (0.08)
Dummy Variable - Radioactive	0.205 (7.60)	0.033 (1.00)
Dummy Variable - Hazardous Wastes	- 0.133 (5.34)	- 0.178 (5.70)
Dummy Variable - Rated Unsatisfactory	0.425 (8.29)	0.002 (0.03)

+ The coefficient on miles is compared against 1 so as to determine the effect of fleet miles on accident rate per mile.

explosives and poisonous materials are hauled by the very largest carriers, with an average size two or more times the overall mean in terms of fleet miles. These firms are also more likely to be general freight firms; they carry hazardous materials as well as other commodities, perhaps as part of a less-than-truckload business. In contrast the bulk haulers of hazardous materials in tanks are about one-third the size of the average hazardous materials firm. Tank truck firms rarely transport general freight and many of them are private rather than for-hire common carriers.

Hazardous Commodity Hauled. This subsection reports on the percentage effects of hauling different types of hazardous cargoes on accident, and fatality and injury, rates. The effects are derived from the multiple regressions. As such they represent the effects of carrying a specific hazardous material category over and above the effects of the firm characteristics reported above. For example, the effect on accidents of carrying liquids in tanks makes allowance for the fact that tank truck carriers are relatively small and that small firms tend to have higher accident rates.

The percentage effects on accident rates, derived from the coefficients in the multiple regressions, are shown in table 3. The most obvious conclusion that can be drawn from the table is that carriage of some types of hazardous materials is characterized by accident, and fatality and injury, rates that are significantly different from the average. The flat $300 fee will prove to be an ineffective device for ensuring that hazardous materials shipments that pose the highest risk to society bear the highest proportion of the costs of emergency response.

As to the specific hazardous commodities, we note that carriers of gases in packages, and liquids in tanks, appear to pose the greatest threat. They have a rate of accidents, and fatalities and injuries, that is 10% higher than that of carriers who do not haul these commodities.

Carriers of gases in tanks have a rate of fatalities and injuries that is no different from that of carriers that do not haul this commodity group. However, the rate of reportable accidents is 15% less. The difference in the two percentages suggests that the carriers of these products tend to have accidents that involve high rates of personal injury and death.

Carriers of radioactive materials appear to have a high reportable accident rate, one that is 23% above that of firms that do not carry commodities in this group. However, it is likely that this finding is due to scrupulous recordkeeping by this type of carrier, because their rate of fatalities and injuries is not significantly different from that of other carriers.

Carriers of hazardous wastes have significantly lower accident, and fatality and injury, rates than carriers who do not haul this commodity.

Severity of Accidents for Different Hazardous Materials

The analysis in the preceding section only gives an indication of the frequency with which accidents occur, and some indication of the severity of the accidents. However, measures of fatalities and injuries do not give a full representation of the

Table 2: Comparison of Firms Hauling Various Hazardous Cargoes (in descending order of fleet mileage)

Commodity	% Long Distance	% General Freight	% Private	Fleet Miles
Radioactive	64	54	30	22,100,000
Explosives	62	44	50	10,100,000
Poisons	63	45	43	8,600,000
Hazardous Wastes	75	13	52	5,100,000
Other Hazardous Commodities	64	35	55	4,100,000
Gases in Packages	54	27	70	3,900,000
Liquids in Packages	63	34	57	2,700,000
Gases in Tanks	51	5	75	1,400,000
Liquids in Tanks	54	5	73	1,100,000
Average	60	27	61	3,600,000

Table 3: Effect on Accident Rates of Hauling Specific Hazardous Commodities (in descending order of effect on fatalities and injuries)

	Predicted Percent Effect on	
	Reportable Accidents	Fatalities & Injuries[1]
Gases in Packages	+12.2%*	+10.4%*
Liquids in Tanks	+ 7.4%*	+ 9.0%*
Radioactive	+22.8%*	+ 3.4%
Explosives	+ 1.5%	+ 1.1%
Poisons	+ 2.5%	- 0.2%
Liquids in Packages	- 1.9%	- 1.5%
Gases in Tanks	-15.5%*	- 3.7%
Hazardous Wastes	-12.5%*	-16.3%*

Notes

* Indicates statistically significant, from firms who do not carry this commodity, at the 5% level.

[1] For audits conducted prior to November 1, 1990.

type of emergency response that may be needed for different types of hazardous materials. Reference to the United States government's *Emergency Response Guidebook* or the Canadian government's *Dangerous Goods Initial Emergency Response Guide* provides more information on the specialized protective clothing and extinguishing agents that must be used for different types of hazardous materials, and on the area around an incident that must be evacuated. Clearly information of this type should be combined with our findings on accident frequency when setting license fees.

3. A PROPOSED ALTERNATIVE SYSTEM OF FEES

In setting its license fee DOT selected certain categories of hazardous materials and levied a flat $300 annual fee on the carriers of these materials. Some people may argue that the setting of a flat license fee has favorable safety implications because it discriminates in favor of large trucking firms and those who specialize in the transportation of hazardous materials. We find that accident rates decline with firm size, and that firms that specialize are safer than general freight firms. If the specialized hazardous material carrier is also a private carrier then the accident record is even better. However, the fee clearly discriminates against small carriers. It also discriminates against shippers and receivers of hazardous materials who, by the nature of the size of shipments they make or their locations, cannot use large or specialized carriers. Even though the $300 fee is modest, it is a barrier to entry. Discrimination in favor of large firms can lead to oligopoly and increased shipping rates. It is possible that the increased costs of shipping may exceed the benefits from a reduced number of accidents.

More important, we argue that the flat fee system fails to take account of the actual differences in the number of accidents and severity of the accidents of the different commodity groups and the kinds of motor carriers that transport them. In this section of the paper we discuss a proposed system of fees that would better ensure that individual motor carriers internalize the full costs of accidents. By doing so society will encourage motor carriers, and possibly shippers, to make investments in safety that will bring them closer to socially optimal levels. Our discussion falls into three categories: recovery of variable costs, the structure of fees to raise revenues to provide additional and higher quality emergency response, and the disbursement of such revenues.

Recovery of Variable Costs

The first part of this paper made the point that there are certain types of costs associated with accidents that are not usually recovered from the offending party. Public agencies may bear the costs of cleaning rivers and lakes, and restoring wildlife and vegetation. The highway pavement, street furniture and utility infrastructure may need to be replaced or repaired. Police officers and other officials may have to work overtime if neighborhoods have to be evacuated. Evacuations impose considerable

costs on social service agencies, and on the households and businesses involved. Fire departments incur variable costs if overtime or attendance fees have to be paid and when specialized chemicals or foams are used.

A trucking firm or other party that causes an accident should be presented with a bill that covers all of the directly measurable variable costs incurred in coping with the accident and in repairing the damage done to the environment.

Annual Fees

We hold that annual fees for trucking firms should be large enough to cover a certain proportion of the special facilities that have to be available to cope with an accident. That proportion should reflect the percentage of hazardous materials truck accidents in which the truck was at fault. These fees are necessary because a fire department that responds to hazardous materials accidents, as well as residential and commercial fires, is a different fire department than one that only has to respond to the latter. It is a department that is more expensive to equip, staff, operate, and manage. As discussed in the first section of this paper, the fire department may have to purchase more or higher grade equipment, own special protective clothing, and perhaps rely less on volunteer labor. In addition, there are recurrent annual expenses associated with sending staff to specialized training courses and conducting practice sessions.

To give the correct incentives to motor carriers, the system of fees should reflect that transporters of specific hazardous materials that have higher frequencies of accidents and/or pose greater risks when accidents occur should pay more than firms that pose lower risks or have accidents less frequently. Empirical evidence of differential accident risk and severity was presented in part two of this paper. Based on this analysis, we suggest that the fee structure should have the following features:

1. The larger the firm the larger the fee. However, the fee should increase at a declining rate. That is to say that while large firms will pay more than small firms, the implicit fee per mile will decline with firm size. All evidence suggests that accident rates decline with the annual mileage run by a firm.

2. The higher the proportion of a firm's business that is hazardous, the higher should be the fee. The only modification to this rule is that firms that specialize in hazardous materials should pay a lower fee than those that transport hazardous materials as part of a general freight business, or those that carry many hazardous materials. Unfortunately, neither the researchers nor DOT have any data with which to determine the split of hazardous to non-hazardous cargoes.

3. Firms who primarily transport hazardous materials over short distances in urban areas should pay a lower fee. Our findings are that urban accidents, while occurring relatively more frequently, are primarily minor in nature. Serious accidents occur with a higher frequency on the open road in less populated areas. In

addition rural areas are more likely to need assistance in training volunteer fire departments and providing the types of specialized equipment that they would not ordinarily need.

4. Private carriers should pay fees that are about one-third less than for-hire carriers.

5. Firms that have an unsatisfactory safety audit rating are now banned from transporting hazardous materials (Sanitary Food Transportation Act, 1990). It has been argued that the safety audit was never intended to be used as a barrier to entry, and that it is not appropriately used for that purpose (Kenworthy, 1993). We argue that it is not necessary to enforce a ban if firms bear the full costs of accidents, and firms with unsatisfactory ratings pay substantially higher annual fees. Even though we find that carriers with an unsatisfactory rating do not have a higher incidence of fatalities and injuries, they do have a 50% higher rate of accidents compared with firms rated conditional or satisfactory. Accidents that only involve property damage still require attendance by response personnel and handling of any spills.

6. The fee should reflect the accident risk of the specific hazardous material(s) carried. In setting this schedule of fees one should consider frequency of occurrence information, such as that contained in table 3, and knowledge of specialized equipment and training that is necessary for particular commodities. On the basis of the analysis in this paper, carriers of bulk liquids in tanks and gases in packages should be paying high fees while carriers of hazardous wastes should have relatively low fees.

We recommend that the fee be based on the following information collected from applicants: annual firm mileage (or other surrogate such as number of power units); approximate proportion of the firm's ton-miles in each of several broadly defined hazardous commodity groups; private carrier status; and proportion of drivers on long-distance trips. With the exception of the information on the proportion of ton-miles, this information is already collected as part of the census data held on all known carriers by DOT.

Econometric analysis of accident data, such as that reported in this paper, would then allow DOT to produce a simple multiplicative equation by which it could determine the appropriate fee to be paid. For example, the fee equation might be something like:

Base fee
x 0.96 x log of annual mileage
x 0.7 if a private carrier
x 1.5 if greater than 50% of drivers are on long-distance trips
x 1.5 if an unsatisfactory audit rating
x 1.1 x proportion of ton-miles that are hazardous liquids in tanks
and so on.

Calculation of the fee could then be made by computer in a similar fashion to the well known and accepted way that insurance agents calculate automobile premiums. If this system appears to be too complex for practical implementation, we recommend that a coarser schedule be derived based on bands of firm size, principal hazardous commodities carried and private carrier status, and presented in matrix form.

Disbursement of Funds

The primary purpose of this paper is to make suggestions about a system of fees and charges for accidents that would be an improvement over the flat fee DOT has adopted. However, a brief discussion of revenue needs and disbursement policies is in order. We focus on the annual fee in the discussion of revenue because the charging of variable costs will obviously be related to the amount of harm caused in individual accidents.

HMTUSA permits DOT to make grants to local response agencies to fund training and planning for hazardous materials accidents. HMTUSA does not have any provision for using license fees to provide funding to local authorities to purchase specialized equipment. This is a serious deficiency. There is a conscious effort being made by transportation risk management professionals and politicians to route hazardous materials away from populous areas. The lightly populated counties and small towns in the vicinity of these alternative routes do not normally have the amount and kinds of specialized, expensive equipment needed to deal with an accident. In addition, these areas do not receive any of the direct benefits, such as employment or tax revenues, of hazardous materials production and the use of such materials as intermediate goods. These communities should also receive funds to pay for additional and more expensive equipment needed to respond to accidents.

Not all of these monies should be raised from the trucking industry. The truck is at fault in only a proportion of road accidents involving hazardous materials. Other at-fault parties such as motorists and pedestrians should bear a proportionate share of the financial burden. This could be achieved by a contribution from general tax revenues, or a requirement that states match grants from the federal government out of a surcharge on automobile registration fees or a tax on insurance premiums.

It is beyond the scope of this paper to discuss the total annual revenues that need to be collected. Clearly there is some economically optimal provision of first response. DOT will obviously need to have some standards which it will use in approving disbursement to individual local agencies. Criteria will include the volume of hazardous materials in the locality, the nature of any specific material that is predominantly shipped in the area, the current equipment and staffing of the fire department, and the availability of such equipment and expertise by neighboring departments. In the event that certain routes become designated as hazardous materials corridors, standards may have to be developed as to the type of first response that should be available and the distance between qualified first responders.

CONCLUDING REMARKS

Economists argue that firms will make the socially correct decisions on prevention of accidents when they must bear the full costs of incidents that they cause. Currently some of the costs of environmental cleanup are borne by the public, as are all the costs of emergency response provision. The $300 annual fee for transporting certain types of hazardous materials that is being implemented by DOT is clearly a step in the right direction. However, we believe that an improved system of fees can be devised that would produce even greater benefits. Annual fees should reflect the expected costs of emergency response efforts. We have determined that these costs are related to the types of hazardous materials being hauled and the types of carriers that haul them. Such a system would more faithfully reflect the mandate given to DOT by the enabling legislation (HMTUSA). In addition, public agencies should be aggressive in billing motor carriers or other at-fault parties for all identifiable costs incurred in dealing with an accident. These costs include environmental restoration, extinguishing agents used, repair of highway facilities, and the costs of evacuating neighborhoods in the vicinity of accidents.

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APPENDIX: THE POISSON TECHNIQUE AND VARIABLES EMPLOYED

Analytical Method

In our empirical analyses we adopt a type of regression technique based on the Poisson distribution in preference to the more common, ordinary least squares (OLS) approach. Professional opinion suggests that the Poisson distribution is more appropriate when dealing with discrete count data (Cameron and Trivedi, 1986; Hausman, Hall and Griliches, 1984). In the Poisson formulation the number of accidents is the dependent variable; the explanatory variables are multiplicative; and one takes the exponent of a coefficient in order to interpret it. Exposure to accidents, interpreted as truck miles in our study, is one of the explanatory variables. This contrasts with OLS style regressions which typically have accident rates (accidents per mile) as the

dependent variable. The Poisson regression is by definition non-linear and fits an exponential curve to data.

As measures of goodness of fit, the percentage of variation in the dependent variable explained by the regression and the log-likelihood statistic are typically presented. The latter statistic is usually compared to the log-likelihood of a regression with only a constant. However, because accidents are heavily related to exposure we felt that the correct base would be a regression with a constant and the log of fleet miles.

Variables Employed

The Accident Experience of the Firm in the Previous 365 Days. Accident data are notoriously unreliable in the trucking industry. The widely used national truck accident database of the DOT's Office of Motor Carriers is flawed because accidents are self-reported. It is generally believed that there are serious inconsistencies and under-reporting of damage-only accidents. Our data come from questions asked directly of managers by inspectors, and therefore should be more reliable. Two measures of accidents are used. The first is called "reportable accidents." Reportable accidents are defined as accidents involving a fatality, an injury, or more than approximately $5,000 in property damage. We also use the total fatalities and injuries measure in our analyses, but must then limit ourselves to the audits conducted prior to November 1, 1990 because DOT ceased to collect these data after this date.

The Log of Total Fleet Miles of the Firm in the Past Year. We use these data to capture both the amount of exposure to accidents and any firm size effects on accident rates. Testing of the coefficient against 1 determines whether accidents increase more or less than proportionately with miles. Inclusion of this variable allows us to colloquially refer to "accident rates" when interpreting the coefficients on other explanatory variables.

The Percent of Drivers Employed on Trips over 100 Miles. We hypothesized that firms whose primary work involves short distances, typically in urban areas, have a different accident experience from firms whose operations primarily involve long-distance service, either on the interstate highway system or rural highways. Urban firms may be involved in a higher number of accidents, but many of these involve minor amounts of property damage which are not included in the federal definition of a reportable accident. This variable cannot be expressed in logarithms because several firms report zero long-distance drivers.

Private Carrier Status. We use a dummy (0-1) variable to indicate if the firm is a private carrier rather than a for-hire carrier.

The Type of Goods Hauled. The nine categories of hazardous materials that were used in the analysis are shown below, with the aggregations that were necessary to avoid collinearity problems being shown in parentheses.

- Explosives (combination of categories explosives A, explosives B, explosives C, and blasting agents)
- Liquids in tanks (flammable liquids, corrosives, oxidizers and combustible liquids)
- Liquids in packages (flammable liquids, corrosives, oxidizers and combustible liquids)
- Gases in tanks (flammable gas, non-flammable gas)
- Gases in packages (flammable gas, non-flammable gas)
- Poisons (poison A, poison B)
- Radioactive materials
- Hazardous wastes
- Other hazardous commodities (flammable solid, organic peroxide, irritating material, "other regulated materials," etiologic agent, "hazardous substances," and cryogenics)

Performance on the Federal Safety Audit. Federal and state inspectors visit the operating bases of carriers and make assessments of their compliance with federal safety regulations and safety management policies with regard to maintenance, and driver hiring and training. The inspectors examine records and interview management officials, but do not actually inspect any equipment or test drivers. The inspectors have a standard list of 75 questions. They mark a pass or fail on each question, but can also append comments and supporting documentation. The carrier is then rated as satisfactory, conditional or unsatisfactory based on the answers to the questions, and a weighting scheme that is not known to the public. Firms that appear to have questionable safety practices, but have not actually violated federal regulations, are typically rated conditional pending further investigation. For the purposes of this paper, we represent the audits by a dummy variable to indicate firms that are rated unsatisfactory. Summary statistics indicate that satisfactory and conditional firms have broadly similar accident rates, while those for unsatisfactory firms are much worse.

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