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16. Abstract

This report surveys different types of financing alternatives for highway and aviation expenditures. Included among the taxes and fees reviewed are motor fuel taxes, license and registration fees, weight distance taxes, congestion taxes, assessments and impact fees, parking fees, and private donations. Criteria for evaluating different taxes were surveyed, and several standard criteria were used to evaluate financing alternatives. Criteria are divided into two groups: (1) basic criteria, including equity, efficiency, and revenue potential, and (2) practical criteria, which includes acceptability, administrative feasibility, and applicability. Motor fuels are found to score very high on all criteria. Even though most equity analyses find that motor fuel taxes are regressive with respect to income, evaluation with respect to total expenditures shows that expenditures on gasoline, and thus on gasoline taxes, tend to be quite proportional to total expenditures at all levels of income. Registration fees in Texas are found to be relatively high for passenger cars and relatively low for trucks. Congestion fees and weight-distance taxes are rated quite high on both equity and efficiency criteria, but are not currently rated as high on the practical criteria. Additional study of these taxes is warranted. Other types of financing alternatives that are discussed include toll roads, tire excise taxes, general sales taxes, property taxes and fees, severance taxes, income taxes, lottery revenues, special benefit fees, private financing, and debt financing.

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EVALUATION OF FINANCING ALTERNATIVES FOR TEXAS TRANSPORTATION

by

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and
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Research Report 1277-1F
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Financing Alternatives for Texas Highways

Sponsored by

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Texas Transportation Institute
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College Station, Texas

METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	2.54	centimeters	cm
ft	feet	0.3048	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	6.452	centimeters squared	cm^2
ft^2	square feet	0.0929	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
mi^2	square miles	2.59	kilometers squared	km^2
ac	acres	0.395	hectares	ha
		MASS (weight)		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		VOLUME		
fl oz	fluid ounces	29.57	millimeters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.0328	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

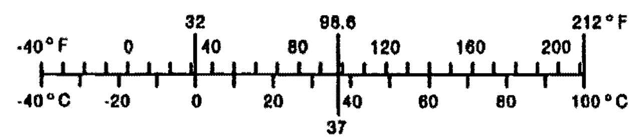
Note: Volumes greater than 1000 L shall be shown in m^3.

These factors conform to the requirement of FHWA Order 5190.1A

*SI is the symbol for the International System of Measurements

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
yd	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
yd^2	kilometers squared	0.39	square miles	mi^2
ha	hectares (10,000 m^2)	2.53	acres	ac
		MASS (weight)		
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1000 kg)	1.103	short tons	T
		VOLUME		
mL	millimeters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



ABSTRACT

This report surveys different types of financing alternatives for highway and aviation expenditures. Included among the taxes and fees reviewed are motor fuel taxes, license and registration fees, weight distance taxes, congestion taxes, property taxes, assessments and impact fees, parking fees, and private donations. Criteria for evaluating different taxes were surveyed, and several standard criteria were used to evaluate financing alternatives. Criteria are divided into two groups: (1) basic criteria, including equity, efficiency, and revenue potential, and (2) practical criteria, including acceptability, administrative feasibility, and applicability. Motor fuels are found to score very high on all criteria. Even though most equity analyses find that motor fuel taxes are regressive with respect to income, evaluation with respect to total expenditures shows that expenditures on gasoline, and thus on gasoline taxes, tend to be quite proportional to total expenditures at all levels of income. Registration fees in Texas are found to be relatively high for passenger cars and relatively low for trucks. Congestion fees and weight-distance taxes are rated quite high on both equity and efficiency criteria, but are not currently rated as high on the practical criteria. Additional study of these taxes is warranted. Other types of financing alternatives that are discussed include toll roads, tire excise taxes, general sales taxes, property taxes and fees, severance taxes, income taxes, lottery revenues, special benefit fees, private financing and debt financing.

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SUMMARY

Texas currently depends mainly on motor fuel taxes and license and registration fees for financing highways. This combination of taxes has been accepted by the public and has provided sufficient revenues for financing major highway improvements, even though there are many unmet needs in the State. In Texas, gasoline is taxed at the same rate as diesel and, compared to most other states, registration fees for passenger vehicles are relatively high compared to those for trucks. This tax structure with dependence on motor fuels taxes and registration fees has resulted in heavy trucks paying less than their fair share of highway cost responsibilities. Other limitations of the current tax system are that pollution and congestion externalities are not explicitly considered. There is a lack of a general procedure for determining property owner responsibility for additional public costs due to development, and for coordinating private donations and road projects with public road system planning. While the state is constrained from the use of debt to finance capital investment, Texas' local jurisdictions lead the nation in the size of their debt burden.

Given the high return on highway investments in Texas, it is recommended that overall highway taxes be increased to provide increased funding for highways. It is the conclusion of this study that an increase in motor fuel taxes should be strongly considered for raising this revenue because of the equity, efficiency, and administrative feasibility of this tax. This might even be implemented with a small decrease in registration fees for passenger vehicles and an increase in registration fees for trucks, since registration fees for passenger vehicles are high relative to those for trucks, as compared to these taxes in other states.

It is recommended that consideration be given to the possibility of variable motor fuel taxes. One possibility would be to index these taxes to the Federal Highway Administration's Maintenance and Operation Cost Index, in a way similar to what is done in Wisconsin and Ohio, perhaps making the 1990 index number the base from which to adjust the twenty cent per gallon state tax. Even with this adjustment, there may be a need to make additional periodic adjustments to account for changing needs and for changing fuel efficiencies. It would also be possible to adjust on a regular basis for changing fuel efficiencies by using national average fuel efficiencies for different passenger vehicle types.

Because of equity and efficiency considerations, it is recommended that alternate fuels always be taxed at the same rate as gasoline and diesel per vehicle mile, as nearly as this can be done.

In addition to reviewing financing alternatives for highways, consideration is given in this report to aviation taxation, and this review is included in Appendix A of the report. Although Texas previously had aviation fuel taxes to generate state revenues for aviation, these taxes were discontinued in the late 1970s when general funds were ample for these expenditures. Given the status of the overall state budget, it is recommended that aviation user taxes be reinstated for funding expenditures of the aviation division of TxDOT.

Given the extensive scope of the study, this report is only able to provide a preliminary review of the subject, covering the basic theory and prominent details of the various fees and

financing options. Many of the taxes and fees covered could easily be the subject of a full blown thesis, and it is hoped that this report will provide guidance in choosing finance options worthy of further study and possible implementation in Texas.

The information provided in this report can aid in the choice of options worthy of further analysis, including detailed studies of potential revenues, legal, political and social barriers to implementation, technical details of administrating and collecting the proposed fees, and potential enforcement problems. A number of potential areas of interest are described in the conclusion to this report. The report covers the basic theory behind taxation, cost-benefit analysis and cost allocation procedures. Motor fuel taxes, weight-distance taxes, and congestion taxes are given the most detailed treatment because of their current and/or potential importance to a highway finance system. The various options for private financing are reviewed; these options are potentially most important to regions experiencing rapid growth.

IMPLEMENTATION STATEMENT

This report should be considered a preliminary review of current highway taxation practices in the United States and specifically in Texas. While there have been a number of suggestions made concerning possible policy actions, the resources available for this study were insufficient to provide a detailed analysis of these options. Therefore, this implementation statement includes suggestions for further study that are presented in the hope that TxDOT or the Texas legislature may see fit to follow up and sponsor the necessary research that would aid in the increased rationalization of highway finance in Texas.

* TxDOT should consider the possibility of variable motor fuel taxes. One possibility would be to index these taxes to the Federal Highway Administration's Maintenance and Operation Cost Index, in a way similar to what is done in Wisconsin and Ohio, perhaps making the 1990 index number the base from which to adjust the twenty cent per gallon state tax. Even with this adjustment, there may be a need to make periodic adjustments to account for changing needs and for changing fuel efficiencies. It would also be possible to adjust on a regular basis for changing fuel efficiencies by using national average fuel efficiencies for different passenger vehicle types.

* Given the high return on highway investments in Texas, highway taxes should be increased to provide better highways in Texas. It is the conclusion of this study that an increase in motor fuel taxes should be strongly considered for raising this revenue because of the equity, efficiency, and administrative feasibility of this tax. This might even be implemented with a small decrease in registration fees for passenger vehicles and an increase in registration fees for trucks, since registration fees for passenger vehicles are high relative to those for trucks, when compared to other states.

* Because of equity and efficiency considerations, alternate fuels should always be taxed at the same rate per vehicle mile (as nearly as this can be done) as gasoline and diesel.

* A special study should determine a schedule for heavy vehicle registration fees under varying assumptions concerning levels of diesel fuel taxes and other possible truck charges, not including a WDT. The goal should be a schedule that would maximize horizontal and vertical equity. Included among the items to be determined should be total revenues under the various options and the economic impact on the trucking industry and the Texas economy.

* The applicability of state or local urban fuel tax surcharges as single peak congestion charges should be examined. The legal requirements to establish these fees and the possibility of earmarking the revenues for projects in the areas where they are collected to reduce congestion should be determined. The possible revenues in each major urban area, the potential barriers to implementation, and the procedures that would be needed to allow such a tax to be established should be calculated.

* Various options should be evaluated for the implementation of a weight-distance tax in Texas. Communications with relevant officials in the state of Oregon and possibly other

states with WDTs should be part of the effort. Review and analysis of the tests of relevant new technologies should be conducted with regard to their applicability to Texas. Revenues and economic impacts should be determined.

* The possibility of a limited congestion fee scheme should be conducted in conjunction with the development of a pilot project in Houston, the most likely candidate for this policy. The city should be involved in the project to ensure cooperation, and a voluntary program instituted on a feasible hihgway segment. Electronic toll collection, including time of day pricing, should be investigated as part of the study.

* The expected impact of the provisions of the 1990 Clean Air Act on fuel use, vehicle use and urban congestion in Texas should be investigated.

* Development of a state impact fee modeling effort should be considered to assist local jurisdictions. The goal would be development of a data base, PC model, and rationale to allow local jurisdiction to impose impact fees if desired without straining their resources. Given economies of scale in information generation, the state is the logical candidate for development of a model, and it would establish a uniform methodology while allowing closer integration of local road and development planning with the state highway planning process.

* The possibility of implementing pollution taxes should be studied. Issues would include a motor fuels tax, a vehicle registration tax, urban pollution surcharges, and differential taxes for various fuels and motor vehicles. This work might be coordinated with the relevant agencies with responsibility for environmental policy in Texas.

* The motor vehicle fuel tax per vehicle mile varies widely for passenger vehicles of different types, sizes, and ages. The possibility of using new technologies to determine and implement more equitable charges per vehicle mile should be investigated.

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CHAPTER I. INTRODUCTION

Unfortunately for the policy maker there is no simple rule to follow when choosing between alternative methods of financing public goods, including highways and other transportation infrastructure. Economic theory provides some guidelines to assist the decision maker in determining the optimal mix of revenue collection methods, but it cannot resolve basic social issues such as fairness, equity, and justice. In addition, the economist often advises the policy maker from the perspective of an omniscient observer, unhindered by the mundane considerations of political feasibility. In the real world the policy maker is often forced to choose second best or third best solutions, and a marginal improvement over the status quo is the best that can be achieved.

This report surveys the various tax instruments used by states and localities to finance road and highway systems. Included among the taxes and fees reviewed are motor fuel taxes, registration fees, weight distance taxes, congestion taxes, property taxes, assessments and impacts fees, parking fees and private donations. An attempt is made to ascertain the full cost of each tax or fee, and its impact on various segments of the population. Full costs include deadweight costs, time costs, and other opportunity costs, as well as the actual monetary transfer. Impacts include both the distributional effect of the tax payment as well as behavior changes by individuals and changes in the rate of generation of externalities such as congestion or air pollution. Costs and benefits of highway programs are also discussed, since consideration of fairness in terms of benefit, or equity in terms of cost, requires assigning costs and benefits and determining their distribution among relevant groups with respect to the relative distribution of the tax burden. The burden of taxes also requires examination of tax incidence, or the final burden of taxes when placed upon developers, land owners, and businesses.

Texas currently depends mainly on motor fuel taxes and license and registration fees for financing highways. This combination of taxes has been accepted by the public and has provided sufficient revenues for the financing of major highway improvements, even though there are many unmet needs in the State. In Texas, the gasoline is taxed at the same rate as diesel and, compared to other states, registration fees for passenger vehicles are relatively high compared to those for trucks. This tax structure, with dependence on motor fuels taxes and registration fees, has resulted in heavy trucks paying less than their fair share of highway cost responsibilities. Another limitation of the current tax system is that pollution and congestion externalities are not explicitly considered. There is a lack of a general procedure for determining property owner responsibility for additional public costs due to development, nor for coordinating private donations and road projects with public road system planning. While the state is constrained from the use of debt to finance capital investment, Texas' local jurisdictions lead the nation in the size of their debt burden.

Given the extensive scope of the study, this report is only able to provide a preliminary review of the subject, covering the basic theory and prominent details of the various fees and financing options. Many of the taxes and fees covered could easily be the subject of a separate study, and it is hoped that this report will provide guidance in choosing finance options worthy of further study and possible implementation in Texas. The current fiscal difficulties faced by the state, combined with the ad hoc nature of the present highway finance system, create a window of opportunity for reformation of the highway finance system. Hopefully, a more coherent system of taxes and fees could be developed, reflecting the generally accepted goals of horizontal and vertical equity while avoiding imposing additional burdens on those least capable of bearing them.

The information provided in this report can aid in the choice of options worthy of further analysis, including detailed studies of potential revenues, legal, political and social barriers to implementation, technical details of administering and collecting the proposed fees, and potential enforcement problems. A number of potential areas of interest are described in the conclusion to this report. The report covers the basic theory behind taxation, cost benefit analysis and cost allocation procedures. Motor fuel taxes, weight distance taxes and congestion taxes are given the most detailed treatment because of their current and/or potential importance to a highway finance system. The various options for private financing are reviewed, given their importance to regions experiencing rapid growth, an important influence on previous Texas policy. Finally, the last two chapters review taxation policy at the State and National level, and then focus specifically on Texas, both state highway and local jurisdiction financing.

CHAPTER II. WELFARE, TAXES, AND COST-BENEFIT ANALYSIS

The Economic Model

The basic method of analysis used in public finance is to study problems of government expenditure and finance from the perspective of a Pareto-optimal general equilibrium world. By Pareto-optimal we mean a situation where at least one person would object to any change in the economic system, implying that no freely negotiated trades are possible. A general equilibrium is one in which all markets are in simultaneous equilibrium (since goods and inputs can be dated, this is usually considered to include markets for future consumption and production as well). Starting from this framework, distortions are noted, and the extent of their impact determined, whether it is an externality such as pollution, a tax to raise revenue (excepting lump sum taxes) or production of a public good. It should be noted that this is a highly theoretical perspective that requires numerous heroic assumptions to be valid; the value of the exercise is to illustrate the general properties of a market system.

The core of neoclassical economic theory (the basis of modern economics) is the concept of consumer sovereignty. Each individual is presumed to be rational (in the sense of choosing the optimal means toward obtaining one's goals, not with respect to the choice of these goals), and has complete knowledge of their preference ordering, which does not change over time. A preference ordering allows one to compare any two packages of goods (which could include psychic goods or leisure) and choose between them. Given that people know their preferences, they will trade with others until they obtain the basket of goods that they prefer above all obtainable baskets. Since inefficiency in the use of resources would allow additional goods to be made available, it is obvious that to reach an optimal state, society would want to eliminate all sources of inefficiency. In the same manner, trades will be made among individuals as long as they are made better off by them. When the opportunity for mutually beneficial trading has been exhausted, then the economy is at a Pareto-optimal point. Therefore, when the economy is efficient, each producer is efficiently utilizing all inputs, and each consumer has reached his maximum level of satisfaction (formally, economists refer to this as utility maximization) given his income.

A competitive market system, will be at an optimum given certain conditions that insure efficiency in production, consumption and exchange. Productive efficiency exists if it is not possible to reallocate inputs to alternative uses such that a net gain in the output of one good is obtained without reducing the output of another good. Technically, this requires that the rate at which outputs can be substituted for one another (output held constant, called the Marginal Rate of Product Transformation--MRPT) is equal for each industry, while each input is used to the point where it produces the same marginal increase in output. Consumption efficiency requires that each consumer maximizes his utility from consuming goods given his income, and if this is true, then each consumer will substitute one good for another at the same rate (Marginal Rate of Substitution--MRS). Each firm, if it is competitive, will produce goods at the point where the price of the good equals marginal cost, and the ratio of the prices of goods will equal the ratio at which consumers trade between goods, the MRS. Note that this does not mean that firms use the same technology or that each consumer has the same taste. It is only at the optimal level of production or consumption that each firm has the same $MRPT_{ij} = P_i/P_j = MRS_{ij}$ for each consumer for any pair of goods. Note that efficiency conditions involve equality of trades (between goods, inputs or outputs) at the margin.

Ideally, in a perfect world the conditions for a general equilibrium would exist, the economy would function perfectly, and there would be no need for governmental intervention, or for that matter, economists. However, the conditions for the existence of a general equilibrium (at least in this optimal sense, since the economy functions more or less imperfectly in the real world, markets are coordinated, but do not operate with perfect efficiency) are quite stringent and often violated. Among the requirements are competitive markets (no firm produces a large enough share of total output such that its production decisions can influence prices) with constant returns to scale (constant returns to scale implies that if you double inputs, then output will be exactly double; while individual firms may not fulfill this condition there is reason to believe most industries do; however natural monopolies exhibit increasing returns to scale or decreasing costs), rational and well informed consumers (there is a substantial body of empirical evidence that challenges this assumption) with static preferences, and no interactions between producers and/or consumers (externalities such as pollution currently lack markets and are therefore not efficiently produced, consumer interaction such as envy, where one person's consumption determines another person's level of utility).

Even if we could assume the world approximated a Pareto-optimal equilibrium, there would still be a role for government. Given free exchange, the distribution of income will be determined by the distribution of initial endowments (wealth, opportunity, talent). Unless we assume that the original endowments were just, there is no reason to consider the Pareto-optimal outcome is just. A world in which one person owned all goods and the others starved could be Pareto-optimal if our miser would refuse any trade with the rest of the world--but few people would consider this an acceptable state of affairs. As we shall see, the issue of income distribution is one of the core problems of taxation since equity is often opposed to efficiency, forcing a choice between two desired goals.

The reason for starting with the general equilibrium framework, despite both its unrealistic nature and its inability to resolve fundamental questions dealing with economic justice rather than efficiency, is that it provides a framework and a language for discussion. Ceteris Paribus (all else held the same) we would like to maximize efficiency as long as it does not conflict with other important goals. In the same manner, while consumers may not be perfectly rational and preferences may be malleable, in a democratic society consumer sovereignty is a good place to start since there is no reason to suppose that government is a superior judge of what people should prefer. Although the real world contains may contain numerous violations of the conditions for a general equilibrium, assuming that our general equilibrium model is a crude approximation of reality gives us a tool to examine the effect of these violations.

Welfare Economics

Economists have attempted some method of measuring the aggregate welfare of society for at least the last century, though concern with social welfare predates formal analysis by thousands of years. The original concept of utility, that employed cardinal measures (based on a measurable scale allowing interpersonal comparisons) assumed one could simply add the utility of the individual members of society to obtain the aggregate measure, and this would be the variable that one would like to maximize. One implication was that if people had similar marginal utility of income schedules (the rate at which utility changes with income) and the marginal utility of income definitely decreased as income rose, then equal income distribution was necessary for a social optimum.

In the 1930s this was replaced by a new concept of welfare economics that insisted that interpersonal comparisons of utility were "unscientific." Cardinal utility was replaced by ordinal utility, which is based only upon the assumption that consumer preferences are consistent and transitive, and allows the relative ordering of alternatives, but not an actual measure of utility. Since interpersonal comparisons were ruled out, the only tool left for judging policies was that of potential Pareto improvements, accepting only changes that made at least some individuals better off and none worse off. Once these possible Pareto improvements were exhausted, we reached a Pareto optimum, where no further improvement can be made. The problem was that in the real world all conceivable policy changes will benefit some individuals and harm others.

The way out of this dilemma was proposed by Kaldor and Hicks. Since utility could not be compared, weigh monetary gains and losses against each other. If there is a net gain the winners could afford to make lump-sum compensation to the losers so as to make everyone better off. This test became known as the Kaldor-Hicks criteria or compensation test, as it identified 'potential' Pareto improvements. The justification for using Kaldor-Hicks was that the benefits and costs of numerous policy changes would be randomly distributed among the population; and therefore, on average, people would be better off.

The problem with the Kaldor-Hicks criteria is that the net benefits do not fall randomly among the population and therefore it is important to determine the distribution of costs and benefits. While the potential Pareto principle was an attempt to avoid interpersonal comparisons, it actually involves a very specific comparison in which utility is measured in dollars, and it is assumed that each person has the same marginal utility of income. Kenneth Arrow demonstrated that given the assumptions of preference theory, a universal social preference ordering (which includes all possible options) that is nondictatorial (no individual's preference is imposed upon society) is impossible.

The solution to this dilemma is that economics provides no solution, only information for the policy maker. The Kaldor-Hicks criteria can provide a mechanism for determining the net aggregate monetary impact of a policy (using consumer preference to assign monetary values to non market goods) independent of its distributional effects, which is the basis of cost-benefit analysis. However, distributional considerations must also be explicitly considered, which may require disaggregation of the analysis given sufficient information to assign costs and benefits to classes of individuals. If there is a policy which unambiguously increases efficiency (the aggregate value of output) and redistributes income in a socially desirable manner, the policy maker is faced with an easy decision. Unfortunately, the normal situation is one in which a variety of policy options are available, each with a different distribution of net benefits. In this case it may be necessary to tradeoff between efficiency and equity.

Externalities

Up to this point we have been dealing with the ideal world of general equilibrium economics. One of the major reasons for government intervention in the economy has traditionally been the existence of some sort of externality in consumption or production, which causes a divergence between private and social cost. A positive externality provides a benefit to third parties that the economic decision maker does not include in his calculations; a negative externality imposes costs on third parties. The total cost of producing or consuming a good then consists of the private cost and the external cost (or benefit), and social cost can be defined as private cost plus external cost. Therefore marginal social cost (MSC) equals marginal private cost (MC) plus marginal external cost (MEC). Since efficiency in both production and consumption requires that price equals MC, an externality will violate this rule, as price no longer equals the marginal social cost. For example, when deciding how much to drive, the consumer does not take in account the cost to society of the pollution he generates; and therefore, he drives more than if he had to pay for the damage caused by automobile emissions.

The classical solution to the problem of externalities is to internalize the damage (or benefit) so the producer or consumer takes the externality into account when making his decisions. By charging a Pigouvian tax, equal to the MEC, private cost is equated with social cost, and the private actor's decisions will be economically efficient from the perspective of maximizing social welfare.

In Figure 2-1 the supply curve for private costs is given by MPC, while the supply curve with social cost included is MSC. The optimal private consumption point is (Pp, Qp), but the social cost is measured along the MSC curve. Therefore, at the optimal private point of consumption, society loses an additional cost, the shaded area between the demand curve and the social supply curve. If suppliers are charged a tax equal to t = Ps - Pp, government revenue increases by the shaded rectangle, equal to the tax times the quantity purchased at the new equilibrium. The area under the demand curve measures the total benefit provided to consumers by the quantity of the good that is purchased, and therefore, we must include the benefit received by consumers that exceeds the price paid (in competitive markets all consumers pay the market price), called consumer surplus. Consumer surplus at the new equilibrium is decreased by the tax rectangle and a triangle equal in size to 1/2(Ps - Pp)(Qs-Qp). The tax paid to the government is a transfer, while the triangle is a net loss of consumer surplus. Since this tax corrects a negative externality, there is no welfare cost associated with its collection as the reduction in social cost is larger than the loss of consumer surplus. However,

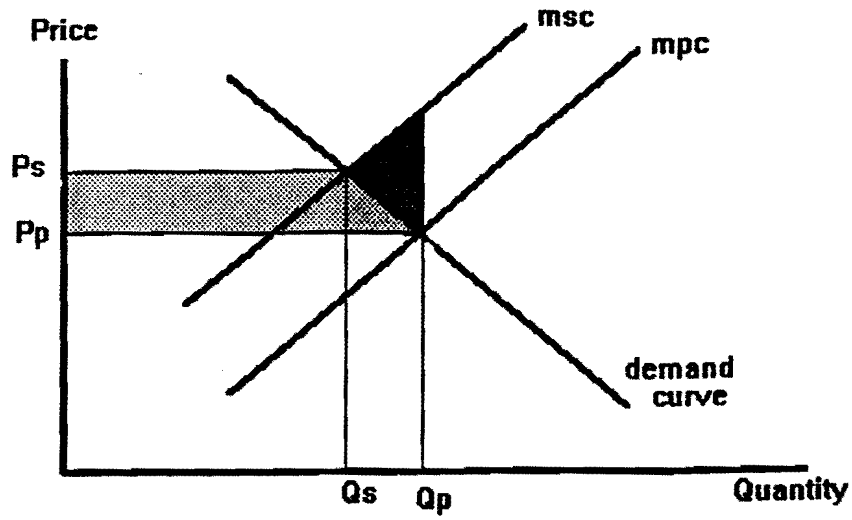

Figure 2-1. Externalities

if we started from a social equilibrium and collected a tax, there would be a net loss of consumer surplus, which is a loss of social welfare. Losses of this sort are referred to as "deadweight losses" because there is a net loss of consumer benefit to society, as opposed to transfers, where consumer benefit is transferred to producers or the government.

Frank Knight first pointed out that the Pigouvian framework for analyzing externalities was oversimplified in his reexamination of the two highway problem. Suppose there are two highways, one in poor condition and the other in good condition but limited in capacity. Trucks will distribute themselves between the two roads until the cost of using the good road, due to congestion, will equal the cost of travel on the poor road. Transferring a truck to the poor road at that point will have no cost because costs are equal on both roads, but there will be a benefit to the remaining trucks on the good road as each will travel faster and thus have lower costs. Therefore, a tax on the good road set at an optimal level that compensates for the congestion costs that the trucks cause one another could optimize traffic over both highways. Knight pointed out that under private ownership of the good road the owner would set tolls in order to maximize revenue, and this toll would be equal to the government toll. In fact, under certain conditions the Knightian approach of maximizing total social welfare will provide superior results to merely equating private costs and social costs. [1]

The importance of property rights to the treatment of externalities was developed in a seminal article by Ronald Coase, which expounded the principle known as the "Coase

[1] Knight, F., "Some Fallacies in the Interpretation of Social Cost," *Quarterly Journal of Economics*, 38, 1924, p. 582-606, reprinted in Arrow, K. and T. Scitovsky, eds., *Readings in Welfare Economics*, Illinois: Richard Irwin 1969 and Mohring & Boyd, "Analysing 'Externalities': 'Direct Interaction' versus 'Asset Utilization' Frameworks," *Economica*, 38, 1971, p. 347-361.

Theorem." This principle has had a profound impact on the economic analysis of law. Coase postulated that if there were no transaction costs, it would not matter who was made liable for an externality. He reasoned that if there was an obtainable social optimum, it did not matter whether the producer of the externality had to compensate the victim, or if the victim bribed the producer. Given that negotiation is costless, the two parties will choose the state of the world in which the total output was maximized and/or costs minimized. The importance of property rights in this case is to determine the distribution of income, not the actions that would be taken. The producer could either pay to curtail the externality or compensate the victim if he was liable; conversely the victim could bribe the producer to curtail the externality or suffer the damage if she was liable. Either way the same solution will be chosen.[2]

Dahlman expanded upon Coase's reasoning by extending it to a world with transaction costs. In fact he redefined the concept of externality, eliminating the comparison with a perfect general equilibrium world by focusing on possible outcomes. Since externalities would be negotiated away if there were no transaction costs, the existence of externalities implies the existence of transactions costs, which are actually information costs. In this case we are already at the obtainable optimum unless the government possesses superior knowledge or lower costs of action relative to private actors, in which case it could assign property rights, levy taxes or employ regulations to shift private actors toward a more optimal state. This becomes a value judgment in which the relative merits of private and public knowledge must be determined.[3] There is still scope for government action in a Coasian/Dahlman world, but the comparison is not between an existing and an ideal state of the economy, but between the existing state of nature and the costs and benefits of governmental action to correct the perceived externality. Since the costs of determining the damage and responsibility for automotive air pollution and congestion effects would be astronomical if it were undertaken by individuals, and negotiation for compensation would be uneconomical, there is a role for government in both information collection and correction of the externalities. However, government action can only be justified if the cost of collecting information, assessing costs and implementing corrective policies does not exceed the benefits derived. There may be situations where an externality is identified but the costs of correction exceed the potential benefits, in which case the status quo is optimal, and a true externality does not exist. One reason economists often support market based solutions such as pollution rights is that the associated decentralized decision-making lowers information costs.

Second Best Theory

In a world with incomplete and asymmetric information, externalities, increasing returns to scale, interdependent utility functions and government interference with markets,it is obvious that there will be some markets that violate the optimality conditions. The question becomes

[2] Coase, R., "The Problem of Social Cost," *Journal of Law and Economics*, 3, 1960, p. 1-44.

[3] Dahlman, Carl, "The Problem of Externality," *Journal of Law and Economics*, 22, April 1979, p. 141-162.

whether it is necessary to account for these markets when determining decision rules for the rest of the economy. The theory of second best was formally presented in an article by Lancaster and Lipsey who pointed out that distortions in one market meant that a second best optimum could not be reached unless there were compensating distortions in other markets.[4] Subsequent discussion of the problem centered on whether this was a theoretical construct or a problem of practical importance.[5] While there are certain conditions under which second best considerations can be ignored, one should be careful to examine interactions between the distorted markets and other prices. For example, in transportation, the congestion and pollution associated with motor vehicles are distortions, as are increasing returns to scale in mass transit and differential taxation of urban parking places. If you lower congestion and increase the amount of driving, you increase pollution.

The importance of second best considerations cannot be overstated in real world economic analysis. While the theoretical economist can control all variables, and including a manageable number of distortions into his model, the applied economist must deal with an economic system which not only contain numerous distortions that are produced by violations of the necessary conditions for a general equilibrium, he must also contend with constraints which are the product of the political system. There will be situations where one could in theory devise a combination of taxes, fees, and subsidies that would approach a near optimal second best solution, only to find that part of this group of instruments will be inoperable due to political constraints. In this case it must be remembered that using the remaining set of instruments may move you away from the optimal solution to the problem if you do not account for the impact of not using the constrained instrument.

Optimal Taxation

The solution for the design of an optimal tax system is trivial; simply assign lump-sum taxes which have no impact on relative prices, including labor and leisure. This tax would have no impact on economic decisions and therefore have no impact on the economy. However, in the real world, there is no way of designing lump-sum taxes which would fail to offend the people's sense of justice or avoid liquidity constraints (what do you do with individuals whose tax burden exceeds their discretionary income, that is, income in excess of that needed to survive?) Obviously, since lump-sum taxes such as poll taxes are rarely used, we are faced with a choice of various distortionary tax instruments to raise government revenue.

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[4] Lancaster, K. and R.G. Lipsey, "The General Theory of Second Best," *Review of Economic Studies*, 24, 1956-57, p. 11-32.

[5] Davis, O.A. and A.B. Whinston, "Welfare Economics and the Theory of Second Best," *Review of Economic Studies*, 32, Jan. 1965, p. 1-14, "Piecemeal Policy in the Theory of Second Best," *Review of Economic Studies*, 34, 1967, p. 323-331, Boadway, R. and R. Harris, "A Characterization of Piecemeal Second Best Policy," *Journal of Public Economics*, 8, Oct. 1977, p. 169-190 and Blackorby, Charles, "Economic Policy in a Second-Best Environment," *Canadian Journal of Economics*, Nov. 1990, p. 748-771.

The starting point for optimal taxation is to assume a set target for government revenue and then to explore the various options for raising this sum. Initially the focus of economists was to minimize the deadweight losses and distortions associated with taxes. Ideally, if one could tax externalities and economic profits (profits above the normal returns, which can usually be attributed to economic rents), then revenues could be obtained without distortionary impacts. Unfortunately, once we have exhausted these sources (assuming away political and institutional constraints on tapping this revenue), we are forced to choose taxing commodities or income.

Frank Ramsey provided the original solution for optimal taxation of commodities by showing that deadweight loss could be minimized by setting the tax rate so as to reduce the consumption of each good in equal proportions, which in the case of zero cross elasticities reduces to setting the tax rate inversely proportionate to the elasticities of demand (elasticity of supply or demand is equal to the percentage change in quantity due to a percent change in price).[6] In the case of roads, one should first charge for the damage to the roads, before setting the revenue tax rate, and then set it relative to other goods according to the elasticity of demand for motor transport. Taxes for complements should be set so as to leave unaltered the proportions in which they are consumed, so taxes should be on both fuel and motor vehicles.

The welfare loss imposed by an excise tax can be estimated by a simple formula:

$$W = (1/2)t^2(PQ)E_sE_d \,/\, (E_s - E_d)$$

where t is the ad valorem tax rate, PQ the expenditure on the good (assuming the tax has little impact on expenditure), and E_s, E_d are respectively the elasticities of supply and demand.[7] If we assume a competitive market (the long-run supply curve is horizontal), then the elasticity of supply becomes infinite given a horizontal supply curve, and this formula reduces to $W = (1/2)t^2(PQ)E_d$. It should be noted that this formula overestimates the welfare loss if the tax has a significant effect on income, but it is a rare excise tax which will have that sort of impact. Since the size of the loss depends on the elasticity of demand, minimizing welfare losses over all commodities requires higher taxes for goods with lower demand elasticities.

Taxing different commodities at different rates introduces distortions between production and consumption. Income taxes have similar distortionary effects as commodity taxes, unless one assumes the elasticity of supply for labor is zero, as leisure is an untaxed good.[8] The fact that goods such as leisure go untaxed should be accounted for, possibly by increasing taxes on

[6] Ramsey, F.P., "A Contribution to the Theory of Taxation," *Economic Journal*, March 1927, p. 47-61.

[7] If a per unit tax T is applied instead of an ad valorem tax, then the formula becomes $W = (1/2)T^2(Q/P)E_sE_d \,/\, (E_s - E_d)$.

[8] Little, I.M.D., "Direct versus Indirect Taxes," *Economic Journal*, 61, 1951, p. 577-584, reprinted in *Readings in Welfare Economics*.

complementary goods.[9] Even with distortions in taxation, it is desirable to maintain efficiency in production, which makes taxation of final goods preferable to taxation of inputs.[10]

While avoidance of welfare losses through design of taxes is a commendable goal, it was found that there was an inherent contradiction with the goal of equity. Goods with low elasticities of demand are usually necessities, which means relatively high taxes on these goods will result in a regressive tax system (a tax system is regressive if the taxes as a percentage of income decline as income increases). If the welfare cost of uniform taxation is small, then it may be socially preferable to optimal taxation.[11] The inclusion of equity complicates attempts to determine optimal taxes, as one then must account for welfare losses, distributional impacts and incentive effects in the analysis.[12]

Taxation in the presence of externalities is more complicated than Ramsey envisioned. It first accounts for the cost of the externality with an appropriate tax, by raising the price of the good to its marginal social cost, and then applies the Ramsey inverse elasticity tax rule. However, the application of a revenue tax reduces consumption of the commodity, and the associated externality also declines. Therefore, the optimal rule becomes to apply the Ramsey rule to a weighted average of private and social costs.[13]

Tax Incidence

Once we add the issue of equity to taxation, not to mention the issue of "fairness," it becomes important to determine who actually pays the tax. There is an illusion that if a tax or regulation that raises costs is imposed upon a business or industry, stockholders will pay the full measure of the tax through reduced profits. In reality, the tax will be passed through and added onto the price of the product depending on the relative elasticities of supply and demand. In addition, the method by which an excise tax is applied will affect incidence.

Looking at Figure 2-2, we see that under either tax scheme the tax drives a wedge

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[9] Sandmo, Agnar, "Optimal Taxation: An Introduction to the Literature," *Journal of Public Economics* 6, July/Aug. 1976, p. 37-54.

[10] Diamond, P. and J. Mirrlees, "Optimal Taxation and Public Production I: Production Efficiency," *American Economic Review*, 61, June 1971, p. 8-27, and "Optimal Taxation and Public Production II: Tax Rules," *American Economic Review*, 61, June 1971, p. 261-278.

[11] Atkinson, A.B. and J.E. Stiglitz, "The Structure of Indirect Taxation and Economic Efficiency," *Journal of Public Economics* 1, April 1972, p. 97-119.

[12] Mirrlees, J.A., "Optimal Tax Theory: A Synthesis," *Journal of Public Economics*, 6, Nov. 1976, p. 327-358 and Cooter, Robert, "Optimal Tax Schedules and Rates: Mirrlees and Ramsey," *American Economic Review*, 68(3), Dec. 1978, p. 756-768.

[13] Oum T. H. and M. Tretheway, "Ramsey Pricing in the Presence of Externality Costs," *Journal of Transport Economics and Policy*, 22(3), Sept. 1988, p. 307-317.

between the price paid by the consumer (Pc) and received by the supplier of the good (Pp). The loss of welfare is determined by the size of the triangle under the demand curve [equal to .5x(Qe - Qt)(Pe - Pc)]. The transfer from consumers to the government is equal to (Pc - Pe)xQt, the transfer from producers to the government is (Pe - Pp)xQt. Notice that when supply is inelastic, most of the incidence of the tax is on producers, while when demand is inelastic the incidence is on consumers. Since supply tends to become more elastic over time, one would expect most of the incidence of an excise tax to be shifted to consumers.

Cost-Benefit Analysis

Cost benefit analysis can be seen as an attempt to apply the principle of the Kaldor-Hicks criteria to public policy decision making, especially with regard to prioritization of public investment alternatives and determination of the net benefits of regulatory policy. As we have seen, the Kaldor-Hicks criteria makes the implicit assumption that all people have the same marginal utility of income. Therefore, when using cost benefit analysis, care should be taken

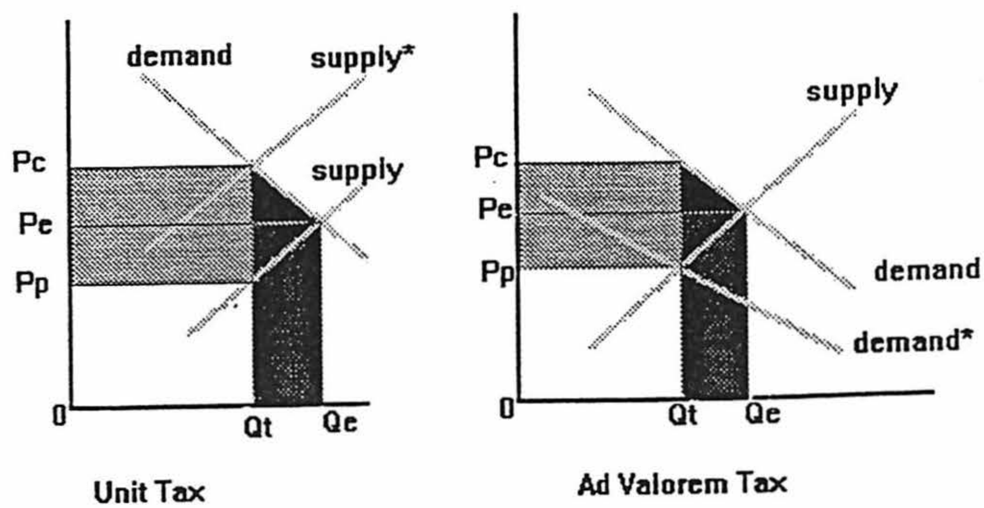

Figure 2-2. Unit Taxes and Ad Valorem Taxes

to consider the distributional effects of a policy, since the mere existence of a larger net benefit is insufficient to justify choosing one policy alternative over another. Even if we assume that income redistribution is a general governmental responsibility, there are costs of returning the income distribution to the structure that existed before a specific policy is implemented, and these costs should be included in the analysis.[14] If the purpose of policy analysis is to provide information to policy makers, using a net benefits total or cost to benefit ratio or rate of return figure does not disclose all information.[15] This is not to say that cost-benefit analysis does not have a legitimate role in policy making; but too often numbers are generated on a computer without careful appraisal of the estimates and the assumptions required for their production.

Costs in economics are usually thought of in terms of opportunity costs, and not cost in the conventional accounting sense. For example, when adding up the various costs of building a highway, market prices can be used for many of the items purchased, such as labor, capital and land costs to build the project and the maintenance costs over the life of the facility, since the market price will be the opportunity cost of purchasing these resources for use on the highway. However some costs will consist of losses to people of opportunities, whether it is the additional time they must consume in following a detour around a construction site, the permanent erection of a barrier that blocks easy access to a park, or an increase in pollution in the region due to increased traffic. These items must also be assigned a value, usually by using a proxy variable, such as the increase in housing values correlated with lower road noise levels.[16]

The same logic applies to the measurement of benefits associated with a project. It is important to distinguish between real and pecuniary benefits. The former consist of an increase in social welfare, the latter merely shift income between individuals. While pecuniary benefits are important in terms of analyzing distributional impacts, they are not actual net benefits. Thus the increase in land values due to a road should not be included along with the time savings for people in that area due to the road. The land values increased because costs decreased, including both results in double counting. Secondary benefits should be included -like if a new road decreases congestion on other roads by diverting traffic.[17]

The most intractable problem in cost-benefit analysis is the determination of the value of costs and benefits that are non-marketed items, such as the value of time, value of a human life and health, aesthetics. Among the techniques applied to this problem have been contingent

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[14] McGuire & Gain, "The Integration of Equity and Efficiency Criteria in Public Project Selection," *Economic Journal*, 79, 1969, p. 882-893, Boadway, Robin, "The Welfare Foundations of Cost-Benefit Analysis," Economic Journal, Dec. 1974, p. 926-939, Harberger, Arnold, "Basic Needs versus Distributional Weights in Social Cost-Benefit Analysis," in Robert Haveman & Julius Margolis, eds., *Public Expenditure and Policy Analysis*, 3rd ed., Boston: Houghton Mifflin, 1983, p. 105-126, and Hau, Timothy, "Distributional Cost-Benefit Analysis in Discrete Choice," Journal of Transport Economics and Policy, 20(3), Sept. 1986, p. 313-338.

[15] Campen, James, *Benefit, Cost, and Beyond*, Cambridge, Mass: Ballinger Publishing Co., 1986.

[16] Nash, Christopher, "The Theory of Social Cost Measurement," in *Public Expenditure and Policy Analysis*, reprinted from D.W. Pearce, *Valuation of Social Cost.*

[17] Haveman, R. & B. Weisbrod, "Defining Benefits of Public Programs: Some Guidance for Policy Analysts," *Policy Analysis*, 2(1), 1975, reprinted in *Public Expenditure and Policy Analysis*, p. 80-104 and Fischhoff, B. and L. Cox, "Conceptual Framework for Regulatory Benefits Assessment," in Judith Bentkover et al., eds., *Benefits Assessment: The State of the Art*, Dordrecht: D. Reidel Publishing Co., 1986, p. 51-84.

valuation, hedonic pricing and shadow pricing.[18] This is one of the most controversial aspects of cost-benefit analysis, and one area where it is absolutely necessary to be open and explicit about the assumptions chosen, since they will often determine the outcome of the analysis.

Since most projects and regulations generate an inter-temporal stream of costs and benefits, it is absolutely essential to discount future benefits and costs to arrive at present values in order to make a valid comparison. This entails another difficult decision regarding the choice of the proper discount rate.

The discount rate to be used for public projects is another area of controversy among economists. If the government activity is displacing private investment funds, use the private opportunity cost (market rate of interest). If it displaces consumption, use the riskless rate of private investment (Treasury bond rate). However, there is also the possibility that people as members of society have a different discount rate than as private actors, leading to a divergence between private and social time preference rates.[19] There is also the problem that certain costs and benefits may not be discountable; can we really say that a human life will be worth less in twenty years? Given that there is no consensus on the values to be used, honesty requires applying a range of values and generating a distribution of results to test for the sensitivity of estimates with regard to assumptions.

Transportation has been one of the areas where the technique of cost-benefit analyses is frequently applied, although in the past some analysts felt there was too little emphasis on using economic techniques in highway project evaluation, while the cost-benefit analysis that were done often employed naive assumptions such as fixed demand for highway services.[20] There are numerous examples and surveys of applications. Hau has used more sophisticated techniques in determining the distribution as well as quantity of consumer benefits, while Witkowski went the other route, providing a simple, personal computer oriented model for local application to highway decision making.[21] McFarland and Memmott rated proposed projects in Texas using cost benefit analysis to determine its relative performance in ranking projects vs. alternative

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[18] Cummings, R., L. Cox and A.M. Freeman III, "General Methods for Benefits Assessment," in *Benefits Assessment: The State of the Art*, p. 161-191.

[19] Feldstein, Martin, "The Social time Preference Discount Rate in Cost Benefit Analysis," *Economic Journal*, June 1964, p. 360-379, Baumol, William, "On the Social Rate of Discount," *American Economic Review*, 58, Sept. 1968, p. 788-802, Mendelsohn, R., "The Choice of Discount Rate for Public Projects," *American Economic Review*, 71, March 1981, p. 239-241, and Bradford, "The Choice of Discount Rate for Government Investments," in *Public Expenditure and Policy Analysis*, p. 129-144.

[20] Gomez-Ibanez, J. and D. Lee, "Economic Evaluation of Highway Investment Needs," *Transportation Research Record* N940, TRB, National Research Council, Washington D.C., 1983, p. 21-27 and Gomez-Ibanez, J. and M. O'Keeffe, *The Benefits From Improved Investment Rules: A Case Study of the Interstate Highway System*, DOT, July 1985.

[21] Hau, Timothy, "Using a Hicksian Approach to Cost-Benefit Analysis in Discrete Choice: An Empirical Analysis of a Transportation Corridor Simulation Model," *Transportation Research*, 21B(5), 1987, p. 339-357 and Witkowski, James, "Benefit Analysis for Sketch Planning of Highway Improvements," *Transportation Research Record* N1116, TRB, National Research Council, Washington D.C., 1987, p. 48-55.

prioritization schemes, and found it improved the quality of the rankings.[22] The Highway Performance Monitoring System (HPMS) has been used to assess benefits and costs of menus of proposed federal projects.[23]

The primary source for determining costs and benefits for highway projects is the AASHTO manual. Developed by the Stanford Research Institute, it provides a cookbook for highway officials to rank projects. The basic methodology is to determine values for user cost factors (requiring periodic updates), and select study features such as the discount rate, unit value of time and analysis period. The project is described and costs estimated, and the unit user costs with and without the project are estimated. User benefits are determined by multiplying the difference between these two user costs by the average volume of traffic with and without the improvement. Convert these benefits to annual benefits, calculate the residual value of the project and discount to obtain their present value and sum. The AASHTO manual does not consider externalities associated with highway transportation.[24]

[22] McFarland, W. and J. Memmott, "Ranking Highway Construction Projects: Comparison of Benefit-Cost Analysis With Other Techniques," *Transportation Research Record* N1116, TRB, National Research Council, Washington D.C., 1987, p. 1-9.

[23] Gruver, J. and W. Reulein, "Estimating the Impacts of Changing Highway Conditions," *Transportation Research Record* N940, TRB, National Research Council, Washington D.C., 1983, p. 1-7.

[24] *A Manual on User Benefit Analysis of Highway and Bus-Transit Improvements*, Washington, D.C.: American Association of State Highway and Transportation Officials, 1977.

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CHAPTER III. ECONOMICS OF TRANSPORTATION

Basic Principles

Transportation has been a traditional area of interest in economics, going as far back as Dupuit's 1844 article, and the work of Pigou (1912) and Knight (1924). Until the 1960s most of the work on transportation focused on the economics of the railroads, both because they were the dominant form of transportation until after WWI (Alfred Chandler credits railroads with the development of the modern corporation) and because railroad regulation created a demand for economic analysis of costs and rates.[25] The increase in urban congestion, the expenditures on the federal highway system, and later, the awareness of the effects of externalities like air pollution revived interest in the economics of highways.[26]

The output of a transportation firm or agency can be considered to be the movement of a commodity or passenger from one point to another over a specified time period, a commodity or passenger trip. For a commodity, the value of a trip depends on the spatial structure of production and consumption. In the short-run the location of production facilities and customers is fixed, and the problem reduces to minimizing the total cost of transporting inputs to factories and outputs to consumers. Costs include the cost of physically transporting commodities plus the expense (cost of capital) of maintaining sufficient inventories to guard against delays in deliveries balanced against the expected loss of production or sales. However, with the advent of just-in-time production methods, this may become a more complex problem as the penalty for delays in the delivery of inputs rise exponentially with the length of the delay.

In the longer run, the transportation of commodities becomes more complex. While consumers are unlikely to choose to locate so as to minimize the cost of traveling to purchase final goods, producers must balance the cost of transportation of both inputs and outputs. This is the reason that major transportation arteries, originally rivers and canals, then railroads and finally major highways, are a dominant influence on locational decisions for industrial investment. Since bulk commodities are cheapest to transport by water or rail (except for liquids such as petroleum for which pipelines are the least expensive alternative for large volumes), it is not surprising that industries such as steel mills and oil refineries are often located on rivers, harbors, and rail lines, allowing inexpensive transport of inputs and final goods. As the value of the good rises relative to the expense of transportation, companies must balance the cost of transporting inputs and outputs, and flexibility in location becomes more valuable. Trucks tend to dominate short-hauls and even long-haul transportation of high value goods as the value of time dominates the cost of transport.

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[25] Chandler, Alfred, *The Visible Hand*, Cambridge: Harvard University Press, 1977 and Thomas McGraw, *Prophets of Regulation*, Cambridge: Harvard University Press, 1984.

[26] Winston, Clifford, "Conceptual Developments in the Economics of Transportation: An Interpretive Survey," *Journal of Economic Literature*, 23, March 1985, p. 57-94.

Competition between modes of freight transportation depends on the type of freight and the existing structure of water, rail and highway infrastructure. Since the highway infrastructure is far more extensive, trucks have the advantage in flexibility, and dominate local and intermediate transport of high value goods. Bulk commodities with high ratios of transport cost to total value are dominated by rail transport (coal is an example), except where water transport is accessible. Therefore rail and truck competition occurs over a relatively narrow range of goods and locations. Even this competition is gradually declining with the increased use of "piggybacking," in which truck trailers are loaded on trains for long distance hauls and then driven to their final destination.

Passenger trips are a more complex good than commodity trips. The value of a trip depends on the destination and the elements of service quality, including comfort, reliability, travel time, time of day, and modal changes (transfers, walking). A long scenic commute is not the same as a drive down a crowded ugly freeway even if they take the same amount of time. The user will value the trip according to these various attributes, and the valuation of various modes will be dependent upon individual tastes, while the choice of mode will also be determined by the individual's income. There is also the peculiar position of the consumer of transportation services as both a customer and a potential producer. As a producer the automobile owner makes a long-term decision when purchasing a car, choosing attributes such as comfort, status, driving enjoyment (handling and acceleration), and safety (airbags, ABS), while trading off between capital, maintenance, energy and insurance costs. Once the car has been purchased and insurance paid, the short-run marginal cost of driving (i.e. producing trip) is limited to gasoline, parking and a complicated interaction between maintenance and depreciation (since cars decline in value with age as well as mileage, depreciation is only partially a per mile charge).

Following Downs, we can assume that the typical consumer wants to minimize the total time spent en route to and from work given four major constraints: income, monetary costs of transportation, residential location and personal comfort.[27] The commuter will only face a choice between automobiles and mass transit when either he lives in an area where mass transit is convenient and comfortable (small time penalty), automobile access is difficult (limited residential parking for example), or he faces an income constraint that makes driving costly (low income combined with high driving, parking costs). In the long run consumers will also choose their residential location partially to reduce the total cost of commuting; it is estimated that living one mile closer to work is worth $380-430 annually for the primary earner, and $620-630 for a working wife with children.[28] For non-work travel, the consumer will have a slightly different set of tradeoffs; time will usually be less valuable, but flexibility may become even more important.

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[27] Downs, Anthony, "The Law of Peak-Hour Expressway Congestion," *Traffic Quarterly*, 16, July 1962, p. 393-409.

[28] Cropper, M. and P. Gordon, "Wasteful Commuting: A Re-examination," *Journal of Urban Economics*, 29, 1991, p. 2-13.

Mass transit systems must make a substantial investment in infrastructure before they present a viable alternative to driving in most cases. A train or trolley system requires track, stations and rolling stock. A subway will also require tunnels, while even a bus system will need sufficient buses to make frequent visits to bus stops, as well as the need to run sufficient routes that allow access to various parts of the service area. While there are situations where a limited system can operate, an example being a train dedicated to moving people from a distant airport to the center of a city, passengers will still need to connect to other transportation options on their arrival. Mass transit systems tend to be characterized by economies of scale, implying diminishing marginal costs. Once a system is in place, the cost of servicing an additional rider (until capacity is reached) is quite low compared to the average cost of service.

There is an inherent contradiction between short-run and long-run costs as a basis for choosing between different transportation mode. In the short-run the automobile may be the cheaper mode (ignoring the value of time for the moment), although it might be the more expensive in the long-run, if people shift modes. The problem is that if people initially invest in automobiles, they will not use mass transit, and therefore the average cost of a mass transit system will remain high, requiring subsidies and discouraging additional users. As Mishan points out, often the withdrawal of substitutes for automobiles increases the benefit-cost ratio for investing in highway infrastructure, and this investment increases the relative advantage of driving by lowering the time cost of travel.[29]

One factor acerbating this situation is that externalities of automobile travel are not charged to drivers; especially congestion and pollution. There are also a number of other externalities that can be attributed to driving including noise pollution, additional costs of accidents, traffic interference with non motorists, visual effects, disruption of neighborhoods, ecological effects, and water and soil pollution.[30] The second problem that makes achievement of an economic efficient solution difficult is that transit authorities usually are not allowed to charge the marginal cost of serving an additional rider, since with diminishing marginal costs this would require running a substantial deficit. As we will see in later chapters, for urban areas these two problems should be dealt with simultaneously, since one solution to congestion is to move people off the roads on to alternative modes of transportation.

Value of Time

The key factor in the valuation of passenger transportation is usually the value of time. The value of time dominates the evaluation of highway project alternatives since most other benefits such as lower maintenance cost, gasoline cost and accident costs tend to be only marginally impacted by the addition of a new road or the repair of an existing one. The value

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[29] Mishan, E.J., "Interpretation of the Benefits of Private Transport," *Journal of Transport Economics and Policy*, 1, 1968, p. 184-189.

[30] Erickson, Ralph, "Elements of Short-Run Marginal Costs of Highway Use," *Transportation Research Record* N858, TRB, National Research Council, Washington D.C., 1982, p. 12-14.

of time also tends to dominate other attributes of travel, and usually determines modal choice. The primary reason for the importance of travel time is that the majority of trips take place under congested conditions.

Traditionally, the value of time was determined by the tradeoff between labor and leisure. The basic methodology was to assume the individual wants to maximize utility as a function of consumption and leisure. Consumption requires monetary income, earned by working. Taxes will affect the value of time, as leisure is an untaxed good, while income taxes lower the effective wage rate.[31] Hensher and others suggest that the behavioral value of travel time savings is sensitive to variations in trip length and the amount of time saved.[32]

Empirical attempts to develop a value of travel time have resulted in a range of values, partially due to the range of method employed. As early as 1976 Hensher was able to group studies as using a macro-choice methodology, product cost approach, revealed behavior, willingness to pay, housing price, trip distribution functions, mode and route choice studies, and general studies.[33] Although a single value of time is used in benefit analysis, there is reason to believe that the value of time varies with a number of factors. It is expected that the value of time will increase with income, that it may increase with the length of time saved in a s-shape curve (AASHTO used Thomas & Thompson's 1970 values, which in 1990 dollars would assign a cost of $1.15/hr for 0-5 minutes, $5.75 for 5-15 minutes, and $9.35 for time savings of over 15 minutes) and that the value of walking/waiting/transfer time is twice the value of in-vehicle time.

The one assertion that can be made with confidence is that the value of time will remain a controversial area of research, and little in the way of consensus can be expected, as shown in Table 3-1, which presents a number of studies of valuation of time used for travel in American cities. Results depend on the time of the study, the method used, and the population examined. The median of these studies is about 65% of the wage rate, which is as good as guess as any. Given an average wage of $12.01, and vehicle occupancy of 1.25 passengers, we have a value per car of $9.75 per hour saved (FHWA used a value of $7.50 per vehicle hour in its urban freeway delay model).

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[31] Forsyth, P., "The Value of Time in an Economy with Taxation," *Journal of Transport Economics and Policy*, 14, Sept. 1980, p. 337-362.

[32] Hensher, David, "The Evaluation of Commuter Travel Time Savings: Empirical Estimation Using an Alternative Valuation Model," *Journal of Transport Economics and Policy*, 10, May 1976, 167-176.
Small, Kenneth, "Studies of the Valuation of Commuter Travel Time Savings: A Comment," *Journal of Transport Economics and Policy*, 12, January 1978, p. 86-89, Hensher, David, "A Rejoinder," p. 90-96.

[33] Hensher, David, "Review of Studies Leading to Existing Values of Travel Time," *Transportation Research Record* N587, TRB, National Research Council, Washington D.C., 1976, p. 30-41.

Table 3-1. Value of Time as a Percentage of Wages (U.S.A. Studies)

Modal Choice Studies	
Mohring [1960]	22-43%
Becker [1965], Lave [1968], Kraft & Kraft [1974]	42%
Lisco [1967]	52%
McFadden [1974]	174%
Route Choice Models	
Claffey, et al. [1961]	65%
Thomas [1967]	40-83%
Thomas & Thompson [1970]	48-78%
Guttman [1975]	97-100%
Speed Choice Model	
Winston & Associates [1987]	63%
Chui & McFarland [1985]	82%

Data from TTI, Preliminary Design For MicroBENCOST Computer Program [1992] and Bruzelius [1979]. Note: $13.86/hr average male full-time wages, $9.16 female full-time wages; assume $12.01 average for all full-time workers [60.7% male, assume 2080 hrs/yr] from 1990 Statistical Abstract, adjusted to 1990 dollars.

Congestion Theory

While the monetary costs of transportation are the most obvious, under certain conditions these are dominated by the value of time spent traveling. Assume a driver of a $20,000 car (spread over 100,000 miles with no remaining value at the end of the car's life) that obtains 20 mpg ($1.20 per gallon) and a $1000 per year insurance bill for driving 10,000 miles. The average cost (ignoring present value considerations and repair costs) will be 21¢/mile, while the marginal cost will be between 6-11¢/mile of driving (depending on whether depreciation is primarily determined by driving or by age of the vehicle). Assuming a time value of $7.80/hr (no passengers), at 60 mph the time cost per mile is 13¢/mile. If the road is sufficiently crowded to slow the vehicle down to 30 mph, the cost to the driver doubles to 26¢/mile. Given the importance of time as a component of travel costs, it is not surprising that there has been so much written concerning traffic congestion. In fact, most of the early economic literature dealing with roads concerns itself with the problem of optimal design of highways and fees to minimize all costs of using crowded facilities, including time. While monetary costs will increase on poorly maintained or more crowded roads (due to increased maintenance, higher fuel consumption, more accidents), time lost to congestion will be the dominant determinant of increased travel costs. Congestion can also be important across modes, whether in the case of the bus mired in traffic, or the airport travelers who spend more time waiting for planes to land and driving to and from airports than flying to their destinations.

Congestion is also the problem that attracts the most public attention to the road system (except of course for car swallowing potholes). A typical example is the article in USA TODAY, (7/14/92, p. 7a), "Congestion Clogs 40% of Urban Highways." In the past the solution was to build additional roads, but even as early as 1962 Downs explained why expansion of capacity was doomed to fail with his Law of Peak-Hour Expressway Congestion. As the highway system expands and congestion is reduced, the cost of driving is lowered, attracting additional drivers to the roads until a new equilibrium is reached.[34]

Consider a road that is infrequently used. It will possess one characteristic of a public good in that it will be nonrival in consumption, that is, consumption of the road by one driver will not interfere with use by another driver. The second condition of public goods, nonexclusivity, is not possessed by roads, as toll roads are an example of roads that exclude nonpayers. However if we assume that in general it is costly to exclude people from the total highway system, then this condition holds. Under this condition, the marginal social cost of adding an additional car to the road (ignoring road damage) is zero, since additional capacity will not be required nor will there be any delay caused to other drivers. It is then socially optimal to pay for the road with general funds, taking in account the opportunity cost of public funds. As drivers are added to the road, eventually they will begin to interact with one another, and the road will take on the quality of a congested public good.

There are a number of types of congested situations; simple interaction, multiple interaction, bottleneck, triggerneck, and general density. Single interaction occurs when two vehicles approach closely enough to delay at least one of them, and total congestion delay should vary as a square of the volume of traffic. Multiple interaction occurs at higher density, where speed s is a function of the flow of traffic x: $s = f(x)$. A bottleneck is one where a relatively short route segment has a fixed capacity which is substantially smaller relative to traffic demand. The trigger neck is a bottleneck where backed up traffic interferes with other flows. With general density, congested traffic is diverted to other parts of the system, increasing overall congestion.[35]

The one theme that all congested situations have in common is that under free access, drivers will overuse scarce services, which in this case is the carrying capacity of the roads. One solution would be to privatize the roads, but in the case of roads with imperfect substitutes, owners would be able to raise price above marginal cost, and in many cases to collude in order

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[34] Downs, Anthony, "The Law of Peak-Hour Expressway Congestion."

[35] Vickrey, William, "Congestion Theory and Transport Investment," *American Economic Review*, 59, May 1969, p. 251-260.

to raise prices still higher. The relevant comparison is the welfare cost associated with government intervention versus the costs associated with oligopolistic private ownership.[36] The fact that most roads in capitalistic economies are publicly owned suggests there are strong institutional constraints on privatization, though private ownership of some roads provides a benchmark by which to judge the efficacy of government administration.

We can start with a simple model of congestion, with a representative driver on a typical stretch of urban road. Initially the driver balances speed against gasoline consumption and the probability of an accident (ignore the coercive effect of state troopers on speed). As additional cars enter, the road density (cars per mile) increases and speed declines, and traffic flow is the product of density and speed. There will be a maximum flow that can be considered the capacity of the road, and at the maximum density, trip time approaches infinity. The flow of vehicles off the road or through a bottleneck is the product of the density and speed. Each car entering the road increases the time for all the cars on the road by increasing density, even though the driver takes in account only her costs of driving, not the additional cost imposed on other drivers.[37]

Monetary costs for drivers tend to be constant as gasoline consumption is lower at high speeds, but also declines with the alternative acceleration and deceleration associated with dense traffic. The road's maintenance cost should be proportional to traffic density. Total social cost will be the sum of private monetary cost, time cost and road maintenance cost. Consumers use a price consisting of the direct money cost plus the value of the travel time in making their driving decision, thus determining the demand for the road. Optimizing requires maximizing the sum of consumer benefits minus the sum of social costs over all drivers as in the long run, the net benefit from the highway is the gross benefit to consumers minus the total cost of providing services, including time costs borne by consumers.[38] The optimal point will be where the marginal cost of adding an additional driver to the road equals the marginal benefit, that is, where the marginal cost curve intersects the demand curve.

At this optimal point, marginal social cost will exceed the marginal private cost by the the elasticity of variable cost, the rate at which time cost rises with respect to a one percent increase in traffic flow.[39] This is the marginal external congestion cost, optimal toll or congestion toll, the additional time cost that a motorist imposes on other drivers. The total

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[36] Hau, Timothy, *Economic Fundamentals of Road Pricing: A Diagrammatic Analysis*, Transport Division, World Bank 1991.

[37] Walters, A.A., "The Theory and Measurement of Private and Social Cost of Highway Congestion," *Econometrica*, 29(4), Oct. 1961, p. 676-699 and Morrison, Steven, "A Survey of Road Pricing," *Transportation Research*, 20A(2), 1986, p. 87-97.

[38] Mohring, Herbert, "Pricing and Transportation Capacity," in *Better Use of Existing Transportation Facilities*, Transportation Research Board Special Report 153, National Research Council, Washington D.C., 1975, p. 15-21.

[39] Walters, A.A., "The Theory and Measurement of Private and Social Cost of Highway Congestion." *Econometrica*, 29(4), October 1961, p.676-699.

optimal charge would consist of the congestion toll plus the variable road maintenance cost attributable to that vehicle. Charging the congestion toll would equate private cost with social cost, and force off the road drivers whose private benefit from driving at that time is less than the social cost of adding them to the traffic flow. The fact that people have different values of time does not affect this result, although it will have distributional implications.

As models of traffic flow become more realistic, the simple relationship between flow and the congestion becomes more complex. Different models of flow must be used for urban traffic flows than expressways. Dewees used a traffic simulation applied to Toronto and found significant variation between roads, with optimal tolls varying as much as 100 to 1 for the same time period.[40] Else challenged the traditional approach which supposes that the cost of adding to the traffic flow is the relevant measure of marginal social cost. He suggested that the optimum level of traffic should be defined in terms of the marginal cost of adding to the number of vehicles. In this case the speed of a vehicle depends on the density of traffic in front of it when it enters, and the vehicle affects only those vehicles behind it. The optimal congestion tax will then depend on the time of entry onto the road, as cars entering during the beginning and middle of rush hour should have a much higher tax than those toward the end.[41] If one allows commuters to differ in their travel time costs, starting times at work, and costs incurred from early and late arrival, then a time-varying congestion toll can be constructed to eliminate queuing and induce the optimal order of departure for work. However, this implies that estimated benefits are generally biased if computed using average travel-cost parameters and average work start times rather than actual distributions.[42]

Congestion tolls can also play an important role in the long-run, as they provide information about necessary capacity expansion and provide funds to pay for these improvements. When a section of road is under built, there will be a high level of congestion and therefore substantial congestion tolls. This is a signal to use these funds to expand the road, and as the capacity of the road increases, congestion, and therefore congestion tolls, will decline.[43] Newbery shows that if there are constant returns to scale in road construction, maintenance and road use, then the optimal congestion charge will recover the capital costs of the road network and the non-allocable fraction (attributable to weather) of road maintenance expenditure (allocable maintenance would be charged to the responsible vehicles). If heavy vehicles are confined to the slow lanes, and if all road damage is attributable to traffic, then the

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[40] Dewees, "Estimating the Time Costs of Highway Congestion," *Econometrica*, 47(6), Nov. 1979, p. 1499-1512.

[41] Else, P.K., "A Reformation of the Theory of Optimal Taxation," *Journal of Transport Economics and Policy*, 15, 1981, p. 217-232.

[42] Arnott, R., A. de Palma and R. Lindsey, "Schedule Delay and Departure Time Decisions with Heterogeneous Commuters," *TransportationResearch Record* N1197, TRB, National Research Council, Washington D.C., 1989, p. 56-67.

[43] Vickrey, William, "Congestion Theory and Transport Investment," *American Economic Review*, 59, May 1969, p. 251-260.

optimal road user charge will recover the capital costs of the road network and twice the total expenditure on road maintenance.[44]

Stronger roads will have lower maintenance costs but higher construction costs, and the higher construction costs will require higher congestion charges, which is equivalent to more congested roads. The higher congestion fee revenue will cover the extra costs of road strengthening. Jordan points out that only lane capacity is considered in most studies of congestion and investment, but lane width also determines capacity, and the largest user class should pay the marginal increment for both width and roadbed depth.[45]

The other case is when there is no congestion on a road. In this case there would be no congestion tolls, suggesting that the road is over built and should be downgraded or even abandoned. In the case where there is deemed a social value to the road, it is a pure public good (too costly to exclude anyone) and should be funded from general funds like all public goods. One solution as we shall see would be to divert some of the excess funds from full cost pricing of transportation goods to finance these roads.

For congested roads tolls should only be charged during congested periods, as travelers during off peak times are not creating externalities in the form of delays for other motorists. This would result in peak period travelers paying the entire cost of these roads, but since it is the demand for travel during this time that is responsible for the massive infrastructure investments, it should be paid for by those drivers who are responsible for motivating these investments. If the same toll must be charged for all roads, the second-best solution requires building "inefficiently small" urban roads and "inefficiently large" rural roads. The same logic applies to single period tolls, requiring a higher level of "optimal" congestion.[46]

One issue that complicates imposition of optimal tolls is the possible impact on income distribution. Drivers with high time values will benefit, as the extra charges they pay will be compensated by the benefit derived from lower congestion.[47] Drivers with low values of time, who do not need to drive, will lose a small benefit when they are forced off the road by the tolls, but there is no reason for society to subsidize their casual driving. The group that will be hurt the most will be those lower income individuals (lower time value) who do not have an alternative means of travel, who will pay higher tolls but receive a relatively lower valued

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[44] Newbery, David, "Cost Recovery From Optimally Designed Roads," *Economica*, 56, May 1989, p. 165-185.

[45] Jordan, W. John, "The Theory of Optimal Highway Pricing and Investment," *Southern Economic Journal*, 50(2), October 1983, p. 560-564.

[46] Mohring, Herbert, "The Peak Load Problem With Increasing Returns and Pricing Constraints," *American Economic Review*, 60(4), 1970, p. 693-705 and Wheaton, William, "Price-Induced Distortions in Urban Highway Investment," *Bell Journal of Economics*, 9(2), Autumn 1978, p. 622-632.

[47] Cory, Dennis, "Congestion Costs and Quality-Adjusted User Fees: A Methodological Note," *Land Economics*, 61(4), November 1985, p. 452-455.

benefit in lessened congestion. This will not be a consistent burden on the working poor, as most bus passengers during rush hours are also in this socioeconomic category, and lowered congestion will provide benefits to those individuals.

The true impact of a congestion toll requires an assumption about the use of the revenues. If the revenues accrue to the general fund and replace other taxes, there will be a social gain due to the elimination of the deadweight loss that is associated with most forms of taxation. The distributional effect will depend on the decision to replace taxes, as the change in tax incidence could be either progressive or regressive. The one situation where this is not a concern is the case of 'hyper-congestion,' or gridlock, where density exceeds the point of maximum flow. In this case the time savings from a toll would exceed the toll for all conceivable drivers, and the government would gain the toll so that everyone wins.[48]

Economies of Scale in Highway Construction

The issue of economies of scale in road construction is important in designing an optimal tax structure, since it determines, at least in theory, whether optimal taxes will produce sufficient revenue to finance a road system. Unfortunately there is no simple answer to this question; in fact the available evidence suggests that one can find decreasing, constant, and increasing returns to scale. Under constant costs the road authority would just break even with an optimal toll; increasing returns would require subsidization while decreasing returns would produce a profit.

There is sufficient evidence, geometric, engineering and empirical, to presume that rural roads exhibit significant economies of scale. Given that to build the road a substantial right of way must be purchased, adding additional lanes will be less costly than the original lanes. The same economies of scale are available in road thickness; it is cheaper to make a road thicker once a road has been built. Adding a second lane increases capacity by greater than a factor of two, also contributing to economies of scale.[49] These economies of scale would dictate subsidization of rural roads, since long-run marginal cost of providing capacity is declining.

An urban road network would probably exhibit diseconomies of scale for a number of reasons. As the number of roads increases, the number of intersections increases as the square of the number of roads. Therefore there is an increasing amount of roads that must be dedicated to intersections and/or overpasses, and there are additional delays for traffic increasing the time cost of driving. One factor mitigating this effect is the reduction in trip circuitry resulting from increased network density. As the urban road system expands, additional right-of-ways become increasingly expensive since the remaining land must become more valuable. One result is that

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[48] Hau, Timothy, *Economic Fundamentals of Road Pricing: A Diagrammatic Analysis*, Transport Division, World Bank 1991.

[49] Hau, 1991.

the scarce input, land, rises in value as it earns economic rents, justifying taxing property in the downtown district since taxes on economic rent are costless from an efficiency standpoint.[50] Empirical data provides some conflicting evidence with regard to economies of scale. Keeler and Small found evidence of constant returns to scale for a sample of San Francisco Bay Area roads, while other researchers have found increasing returns, but this may depend on the mix of roads examined.[51]

One minor problem can be traced to the existence of indivisibilities in production of roads as one cannot usually provide increments of lanes (though turn lanes, shoulders, etc. are a method of providing incremental capacity). The solution is to allow congestion and associated tolls to rise until it makes economic sense to add the additional lanes. In the real world, most rural highways can be gradually expanded, however some urban expressways will present limited opportunities for expansion other than to increase the road's physical volume.[52] Since actual investment decisions are based on expected traffic over an extended period there is no reason for indivisibilities to be a serious problem unless there is a desire to continuously fine tune congestion taxes.

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[50] Hau, 1991 and Kraus, Marvin, "Indivisibilities, Economies of Scale, and Optimal Subsidy Policy for Freeways," *Land Economics*, 57(1), February 1978, p. 115-121.

[51] Hau, 1991 and Keeler, T. and K. Small, "Optimal Peak-Load Pricing, Investment, and Service Levels on Urban Expressways," *Journal of Political Economy*, 85(1), 1977, p. 1-25.

[52] Starkie, D.N.M., "Road Indivisibilities," *Journal of Transport Economics and Policy*, 16(3), September 1982, p. 259-266.

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CHAPTER IV. CRITERIA FOR EVALUATING HIGHWAY TAXES

Introduction

The determination of what a "good" tax system would be is an exercise in social philosophy, since it includes a number of concerns, of which economic efficiency is merely one of many. Among the most important requirements of a tax system, according to Richard Musgrave are:[53]

1. The distribution of the tax burden should be equitable, that is, everyone pays their "fair share."
2. The excess burden associated with taxes should be minimized.
3. Taxes used for social purposes should have a minimal impact on equity.
4. The tax system should permit fair and nonarbitrary administration, and it should be comprehensible to the average citizen.
5. The cost of administration and compliance should be minimized insofar as this is compatible with other objectives.

These can be compared with the four maxims of Adam Smith:[54]

1. "The subjects of every state ought to contribute towards the support of the government, as nearly as possible, in proportion to their respective abilities; that is, in proportion to the revenue which they respectively enjoy under the protection of the state."
2. "The tax which each individual is bound to pay ought to be certain and not arbitrary..."
3. "Every tax ought to be levied at the time, or in the manner, in which it is most likely to be convenient for the contributor to pay it..."
4. "Every tax ought to be so contrived as both to take out and to keep out of the pockets of the people as little as possible, over and above what it brings into the public treasury of the state..."

These rules tend to reflect fundamental beliefs pertaining to the just operation of an economic system. Perceptions of economic justice can be traced back to the Old Testament and the Greek philosophers, but the basis in American law can be traced to English tradition, which evolved out of the medieval concept of the "just price." This led to a paternalistic model, in which the poor were protected, and direct transactions between producer and consumer encouraged. Gradually, in the United States, the market began to dominate economic

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[53] Musgrave, Richard and Peggy Musgrave, *Public Finance in Theory and Practice*, 3rd ed., NY: MGraw-Hill, 1980.

[54] Smith, Adam, *The Wealth of Nations*, NY: The Modern Library, 1967.

transactions, but there is still a consensus that is behind the legitimate restriction of economic activity. Edward Zajac has distilled these concepts of economic justice into six Propositions:[55]

1. It is generally accepted that every individual has basic rights to adequate food, shelter, heat, clothing, etc. Deprivation of basic economic rights is considered unjust.
2. Equal treatment of individuals is seen as a just basis for policy, especially when common measurements, such as dollars or time, of individual gain or sacrifice are at hand.
3. The retention of a beneficial status quo is considered a right.
4. Society is expected to insure individuals against economic loss because of economic changes.
5. The existence of economic inefficiencies is unjust, especially if they confer benefits on special interest groups who oppose their removal.
6. The fewer the substitutes for a regulated firm's output, and the more the output is considered an economic right, the greater the public demand for government control of the firm.

It is obvious that there are going to be significant conflicts in the implementation of any of these sets of rules. The economic literature provides limited guidance due to the tendency of economists to assume away some of these concerns (usually the cost of administration and compliance, and often the problem of equity) and simply ignore others, such as fairness. The policy maker does not have this luxury since a tax system must be politically acceptable as well as efficient. Nor can we simply conclude that people are irrational in their desire for "economic justice," as the only reason for economic efficiency is that it increases welfare for society in general; if meeting social expectations of justice improves the "quality" of life, then it is quite rational to sacrifice some degree of efficiency in the pursuit of noneconomic "goods."

Benefit Principle

Traditionally in highway taxation the focus of policy has been to satisfy one criteria of economic justice, usually presented as the "benefit principle." This is the concept that people should pay in proportion to benefits received, which is similar to Musgrave's first rule, that people pay their fair share. It is actually a crude attempt to apply Lindahl pricing, that is the principle that the cost of a public good be assigned according to the marginal benefit received by each individual. The problem has always been one of determining the actual benefit received, since it is well known that each individual has an incentive to "free ride" by understating their valuation of the good. In the case of a good with rivalrous consumption, that is, a commodity where only one person can consume the particular unit of the good, the market

[55] Zajac, Edward, "Perceived Economic Justice: The Example of Public Utility Regulation," in Young, H.P. ed., *Cost Allocation: Methods, Principles, Applications*, Elsevier Science Publishers, 1985, p. 119-153.

solves this problem by only providing goods to those persons willing to meet the market price.

Initially, roads (and waterways) were financed locally, and were fairly limited in scope. While this did not guarantee that they would be financed by the beneficiaries in proportion to benefits received, it is obvious that there was a strong correlation; when the farmers in a region banded together to build a feeder road, they had a good sense of their neighbor's contribution and benefit. The same held true for canals and roads that were subscribed to by the economic interests of a municipality. As roads increased in length, toll roads and bridges also provided a means to exact payment from users who benefitted from the improvements. As the road system grew in size, it became necessary to change the basis of finance since one could no longer assure that the beneficiaries were local in nature, while economies of scope discouraged a system of isolated toll roads (the cost of administering a toll road is related to the extent of interconnections with other roads). Eventually a user-pay system evolved, and the benefit principle became a means for assigning charges to various users of the highway system.

A true benefit system of financing is impossible for the reasons presented above; it is unlikely that motorists or landowners would be willing to reveal the true value of the road system to themselves. Willingness to pay is generally difficult to administer with respect to highways; even toll roads only segregate those drivers willing to pay at least the toll, but this does not reveal the total benefit to those drivers who use the toll road. The one important exception is with respect to local financing of highway improvements. The willingness of developers to finance highway improvements (or to be coerced into making contributions) reflects the value of the economic rents that they expect to receive from the project. Even in this case, the assignment of fees tends to reflect the marginal costs imposed upon the system by the development, not the benefit received by the landowners. Therefore, the benefit principle is valuable only in the sense that it justifies imposing fees upon certain individuals or groups, but it is a poor guide to determining the optimal structure (from either an economic or social vantage point) of these fees.

One important application of the benefit principle involves proper assignment of the responsibility of financing local roads. It is well known that transportation improvements can increase property values, especially when they lower commuting time.[56] This increase in property values is directly attributable to the decline in commuting costs, which is why one does not include this increase in cost-benefit analysis, as it is a pecuniary benefit. However, while the increase in the value of land is not an additional benefit to society (except when development of the now more accessible land allows diversion from locations that are less efficient in terms of providing property services), it is a transfer to the property owners. Therefore if one cannot directly tax the commuters using the particular stretch of highway (through a toll, for example), it does make sense to tax the increase in property values to finance the road. This is an example where pursuing economic justice and economic efficiency coincide.

[56] Palmquist, R., "Impact of Highway Improvements on Property Values in Washington State," *Transportation Research Record* N887, TRB, National Research Council, Washington D.C., 1982, p. 22-29.

Highway Cost Allocation

The major premise of the benefit principle is that financing of public work projects that do not provide a uniform benefit should be restricted to the groups that receive benefits. This overlaps quite well with the attitude that different groups should be assigned charges relative to the costs incurred in providing them services. Therefore it becomes essential to develop a methodology for assigning costs to various users. Cost allocation is not the same as marginal cost pricing, as most cost allocation procedures assign costs only partially with respect to marginal cost; the break-even condition and the allocation of joint costs usually result in a divergence from marginal cost.

A good introduction to cost allocation procedures is provided by Peyton Young. The idea of a cooperative game is used in assigning costs, which turns out to be a formalization of the ideas presented in the early literature on cost-benefit analysis. In order to have a fair, equitable distribution of costs, one would like to use rules that would be acceptable to participants if the project had to obtain the cooperation of the customers. This can be modeled as a game where each party can decide whether to participate, and the cost of providing services to the group of participants is less than to each one separately (otherwise the project is inefficient).

Start with a joint cost function c(S) that represents the least costly method of serving the customer, 'c' is called the characteristic function of the cost game. The problem is finding a method to assigning costs when there are joint costs that cannot not be attributed to a specific participant. Among the criteria used for judging cost allocation methods:[57]

1. The sum of charges should cover costs (Completeness).
2. The Stand-Alone Cost Test — Each party should be charged no more than their "stand-alone" opportunity costs (Rationality).
3. Incremental Cost Test — Participants should not be charged less than the marginal cost of including them (Marginality).

If these principles are followed, no participant has an incentive to produce the good on their own since (2) assures that they will receive cost savings by cooperating, while (3) guarantees that no group of participants will be subsidizing other participants. Given these conditions, the core, the set of all cost allocations that hold to these principles, can be determined. Unfortunately it is quite possible for the core to be empty, that is, there are no cost allocations that would fulfill these three rules.

There are a number of methods that can be used to allocate costs. One is the Separable Costs Remaining Benefits (SCRB) method. Each service has a separable cost, equal to marginal

[57] Young, H. Peyton, "Methods and Principles of Cost Allocation," in H.P. Young, ed., *Cost Allocation: Methods, Principles, Applications*, North-Holland, 1985, 1-29.

cost, and an alternative cost, equal to the stand-alone cost of providing the service. Subtract marginal cost from alternative cost to obtain the remaining benefit, and then allocate nonseparable costs (total cost minus the sum of marginal costs) in proportion to the remaining benefits. In effect, each service pays for joint costs in proportion to the savings that result from joint production. The Shapley value is similar to incremental pricing in which each participant joins the coalition on a random basis, and is assigned their average marginal contribution (since incremental costs depend on the order in which participants are added). Other methods focus on choosing a point in the core, since if there are a number of cost allocations that fulfill the necessary conditions, then a system for choosing among them is required.[58]

The practice of highway cost allocation often violates both the principles elucidated by Young and the ideal economic practice of marginal cost pricing. Historically, one of the major techniques used has been the Incremental Method, which allocates costs on the basis of highway design differences necessary to accommodate heavier vehicle classes. The approach was developed at a time when the emphasis was on assigning costs of new highway construction. It was used in the first Federal Highway Cost Allocation Study (1961) and a number of state studies. The incremental method meets the completeness, rationality and marginality requirements, but it is inconsistent, with the results changing if the order in which vehicle classes are introduced is altered.

According to the incremental method, the cost of a highway facility is assigned to axles on the basis of Equivalent Single Axle Load (ESAL) ratings. The pavement cost responsibility for the heaviest axles is determined by assuming that these axles weigh only as much as the second heaviest class, and the cost of the optimally designed road is then calculated given the miles driven by that class (total miles for both classes of axles). The difference between the actual road cost and the calculated cost is then assigned to the heaviest class of axles. Repeat for the third heaviest class (adding to it the mileage of the two heaviest groups of axles), calculate the cost of this road, and subtract from the cost of the second road. This incremental cost is then assigned proportionally by mileage to the two heaviest groups. The procedure is repeated until all incremental costs have been assigned. The actual technique is a bit more complex since ESAL loadings depend partially on pavement thickness, which in turn depends on ESAL loadings and traffic volume, so that an iterative procedure is required.

The problem with incremental costing is that road construction exhibits economies of scale in pavement thickness, which makes the order by which incremental costs are assigned crucial to the outcome of the procedure. Required thickness increases at a slower rate than ESAL loading, so that the thickness needed for additional ESALs is much less than the initial loadings. This means that by removing the heaviest axles first, their associated ESALs are assigned a much smaller pavement thickness and thus cost. However, the choice of the order of axle removal is arbitrary to the extent that road thickness depends on the total ESAL loading. Pavement design methods involve consideration of the entire traffic loading as a whole, and not

[58] Young, 1985.

for an individual class of vehicles, since durability (not strength) is the dominant criterion. Therefore it would be fairer to charge each class of vehicles according to its ESAL miles for thickness.[59] Fwa and Sinha developed a Thickness Incremental Procedure to allocate the cost of the minimum thickness to vehicle classes according to vehicle miles traveled (VMT), then calculate ESAL loadings (which are dependent on pavement thickness) for additional increments of pavement, using the AASHTO Road Test equations. Costs for these increments are allocated according to ESAL loadings by vehicle class.[60]

Another accepted approach is the Proportional or Consumption Method. This method allocates costs in proportion to a measure of relative use or damage caused by the vehicle classes using a highway. While this technique accounts for responsibility for maintenance expenditures it does not take in account the problem of allocating costs of shared facilities. It should be noted that equitable charges for consumption will correspond to short-run average variable cost, which will not usually equal the marginal cost.[61] A problem with proportional allocation is that in theory it may yield cost allocations that violate rationality, though there is no evidence of this in the case of highway cost allocations.

More sophisticated methods that have been proposed are the "Modified Incremental Approach" and the "Generalized Method." The modified incremental method is similar to the SCRB, as it partitions the cost of the facility into 3 parts: 1) the marginal cost of each vehicle class, 2) costs attributable to pairs of participants, and 3) costs attributable to larger combinations of vehicle classes. The marginal cost of each vehicle class is the total cost minus the cost of the road without that vehicle class. The remaining cost attributable to pairs of participants is the total cost minus the cost without the two classes minus the marginal costs of the two classes, allocated proportionally to the VMT for each vehicle class for all pairs. All combinations are included, and the results are invariant to the order of inclusion of vehicle classes. The generalized method expresses the three principles in terms of constraints to a linear programming model, ensuring the solution will be in the core. The core is then reduced by simultaneously increasing the constraints until a single point is reached.[62] The Texas Highway Cost Allocation (HCA) Study uses the Modified Incremental Method for new construction and

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[59] Smith, F. and B. Brogerg, "An Equity Assessment of the Standard Incremental Method," *Transportation Research Forum*, 23(1), 1982, p. 313-322 and Fwa, T.F. and K.C. Sinha, "Thickness Incremental Method for Allocating Pavement Construction Costs in Highway Cost-Allocation Study," *Transportation Research Record* N1005, TRB, National Research Council, Washington D.C., 1985, p.1-7.

[60] Fwa & Sinha, 1985

[61] Markow, M. and T. Wong, "Life-Cycle Pavement Cost Allocation," *Transportation Research Record* N900, TRB, National Research Council, Washington D.C., 1983, p. 1-10.

[62] A. Villarreal-Cavazos and A. Garcia-Diaz, "Development and Application of New Highway Cost-Allocation Procedures," *Transportation Research Record* N1009, TRB, National Research Council, Washington D.C., 1985, p. 34-41.

the Generalized Method for rehabilitation and maintenance expenditures.[63]

The 1982 Federal Highway Cost Allocation Study divided pavement cost according to new road pavement and rehabilitation of old pavement. The cost of new pavement was determined by the designed thickness needed to serve a given amount of ESALs. New pavement costs were then assigned on the basis of ESAL loadings, regardless of the vehicle classes producing the loadings. Rehabilitated pavement costs were assigned according to damage produced by traffic, by ESAL loading according to AASHTO calculated weights, based on a service-life approach. New bridge costs were assigned by the incremental approach, while bridge repairs were considered residual costs since the relationship between repairs and bridge loadings are unknown. Costs that go to all vehicles are minimum width, minimum-thickness costs (residual costs), comprising 35 percent of new pavement costs, allocated through VMT. Width and grading functions are assigned through the incremental approach while right-of-way and other miscellaneous costs are considered residual costs.[64] The Indiana Highway Cost Allocation Study used VMT to allocate minimum right-of-way costs and Passenger Car Equivalent (PCE) VMT to allocate additional width.

One problem with all highway cost allocations is that they are dependent on the optimal highway design, which is based upon data derived from AASHTO tests performed from 1958-1960 in Illinois. However there is some evidence that the original statistical analysis of these tests was faulty, and therefore, calculations of optimal durability, and thus optimal investment, are also faulty. AASHTO specified a nonlinear equation relating pavement quality to axle loadings. Winston and Small reestimated this equation using Tobit analysis and found a less steep relationship between pavement life and axle load, close to a third-power law than to the fourth-power law used to approximate the AASHTO findings. They found a much shorter pavement lifetime for thick pavements, as much as 65% shorter for the standard ten inch pavement. These results imply optimal rigid-pavement thickness approximately 1 to 3 inches greater than the conventional standard, increasing the discounted benefit of investment in thicker pavements.[65] Choice of optimal road thickness involves using a formula to calculate the necessary surface base and subbase thickness, depending on soil support, total traffic loadings, environment, and construction. If roads are built to a sub optimal thickness, then there will be a lower construction cost but higher maintenance costs, and classes of vehicles will be assigned different costs than under optimal construction decisions. The biggest losers are trucks on high volume roads, who when correctly allocated costs, would pay far more under present construction standards than under optimally designed roads.

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[63] Villarreal, A., Burke, D., C. Walton and M. Euritt, *The Texas Highway Cost Allocation Study*, TTI Research Report 390-IF, December 1987.

[64] Mingo R. and A. Kane, "Alternative Equity-Based Methods for Allocating Highway Costs Among Users," *Transportation Research Forum*, 23(1), 1982, p. 306-312, and *State Highway Cost-Allocation Guide*, USDOT, FHA, Oct. 1984.

[65] Small, K. and C. Winston, "Optimal Highway Durability," *American Economic Association*, 78(3), June 1988, p. 560-569.

Vertical and Horizontal Equity

Given that a system of cost allocation is chosen by the state, and costs for various vehicle classes are calculated, the next problem becomes designing the fee system. Traditionally, highway finance has made equity the first principle. There are two considerations for the design of what is commonly considered a fair tax system: (1) vertical equity requires that all vehicle groups pay their fair share of fully allocated costs, (2) horizontal equity requires that vehicles within the same group pay the same amount. Vertical equity will be satisfied if the cost allocation is performed properly, though it will not necessarily provide a pricing system that will guarantee efficiency.

Horizontal equity is usually harder to achieve since it requires far more information to properly design fees. Even if each vehicle class is assigned its share of cost responsibility, assuring that each vehicle within the class will be charged its fair share is an extremely complicated task. The problem is that to make a fee reasonably inexpensive to administer with current technology, it is simply impractical to gather the amount of data needed to assure close correspondence with actual cost on a vehicle by vehicle basis. For example, a weight-distance fee, which would come fairly close to charging trucks their true costs if properly designed, would still have a problem in assigning costs to actual axle load miles. Data on the weight of each load and distance traveled would have to be gathered, along with a record of all roads traveled so that a proper charge, taking in account the difference in costs between highways constructed for heavy travel and lighter roads, could be calculated.

Current practice in designing highway tax systems violates both vertical and horizontal equity to a far greater degree than an optimal system would, even taking in account institutional limitations to fine tuning a highway finance system. Historically, cost allocation was generally ignored when establishing fee systems, and political considerations make adjustments difficult, especially adjustments that raise rates on certain classes of vehicles. The existence of multiple levels of taxation for highways, and the lack of coordination between these levels is another problem in achieving a more equitable system.

The extent of inequity depends on the structure of the tax system, the method used for assigning costs, and the degree of disaggregation of vehicle classes. The trucking industry has supported continued use of the incremental method because it lowers the cost responsibility of trucks, especially heavy trucks. Mingo and Kane found that using the 1982 FHCAS method (on federal taxes and highways), instead of the incremental method, would give a revenue/cost responsibility ratio of 0.69 compared to 0.88 for all trucks, while for heavy trucks (>75,000 lb.) the FHCAS ratio was 0.39 instead of 0.67. Federal and State tax systems can change ratios of revenues to cost responsibilities, as can be seen by Texas ratios with and without federal taxes, as well as a comparison between various states (influenced both by tax systems and cost allocation methodologies). The drastic difference in ratios between all Single Unit Trucks and Pickup trucks points out the dangers of aggregation.(Table 4-1)

The problem of horizontal and vertical equity can be seen in Tables 4-2 and 4-3, which analyze tax revenues from the 1982 Surface Transportation Assistance Act. While there have been some modifications in federal taxes since that time, the general pattern of revenue/cost ratios presented here is still valid. As can be seen, automobiles pay their proper federal share of costs, but trucks tend to vary widely in their ratios, with light trucks overpaying and heavy trucks underpaying, a violation of vertical equity. Horizontal equity is also violated, as the ratio of revenues/cost depend on vehicle mileage, which implies that similar vehicles can have widely varying ratios depending on usage patterns.

Table 4-1. Texas, Other State and Federal User Payments/Cost Responsibilities Ratio

Vehicle Class	1985 Texas Total Revenues	1985 State Revenues	Florida	Georgia	Indiana	Wisconsin
Automobiles	3.08	3.52	1.04	1.03	1.24	0.94
Buses	2.62	2.68	2.55	0.82	0.83	0.62
Single Unit Trucks	0.96	1.02	1.20	1.08	1.13	1.39
Pickups	3.01	3.28				
Other Single Axle	0.29					
Combinations	0.45	0.29	0.54	0.46	0.62	0.89
3-S2	0.53	0.35				
Other	0.21					

Source: Villarreal, Arturo, Burke, Dock, C. M. Walton and M. Euritt, *The Texas Highway Cost Allocation Study*, TTI Research Report 390-IF, December, 1987.

Table 4-2. Comparison of Vehicle Class Responsibility to User Payments Under the 1982 STAA ($Million)

Vehicle Class	1982 Total Revenue	FHCAS Cost	Overpayment (Percent)
Automobiles	5,586.0	5,436.5	+3
Buses	0.0	160.4	
Pickups and Vans	2470.7	2188.2	+13
Combinations:			
>70,000 lb.	1109.0	851.1	+30
70-75,000 lb.	979.1	1097.5	-11
>75,0000 lb.	1300.4	1880.2	-31

Source: Henion, Lloyd and John Merriss, "An Equity Assessment of Federal Highway User Charges," *Transportation Research Record* N967, TRB, National Research Council, Washington D.C., 1984, p. 3-13

Table 4-3. Ratio of 1985 Tax Payments and Responsibility at Various Annual Mileages Under the 1982 STAA

Annual VMT	Automobiles	Single Unit Trucks	>70,000 lb.	70-75,000 lb.	>75,0000 lb.
10,000	1.06	1.25	3.49	3.89	3.27
25,000	1.06	1.00	1.68	1.75	1.46
50,000	1.06	.92	1.08	1.04	0.85
75,000	1.06	.90	0.88	0.80	0.65
100,000	1.06	.88	0.78	0.68	0.55

Single Unit Trucks: average mileage 12,920; ratio = 1.16
Combinations <70,000 lb.: average mileage 36,560; ratio = 1.30
Combinations 70-75,000 lb.: average mileage 62,810; ratio = 0.89
Combinations >80,000 lb.: average mileage 67,960; ratio = 0.69
Source: Henion, Lloyd and John Merriss, "An Equity Assessment of Federal Highway User Charges," *Transportation Research Record* N967, TRB, National Research Council, Washington D.C., 1984, p. 3-13

Tax Incidence

Tax incidence, the final burden of taxation, is important with regard to equity issues. Perception of tax incidence (often erroneous) is an important factor in the politics of taxation, since most interest groups would like to shift the burden of taxation to other groups, and any group that mistakenly perceives its actual burden is at a competitive disadvantage in this struggle. Tax incidence has little impact on efficiency, since if the tax is set at the efficient level, proper decisions will be made by consumers and producers, and there will be no distortionary impacts, though there may be redistributive effects. When we have to deal with a second best world, tracing the incidence of a tax can be important for efficiency considerations since it is necessary to know the effect of the tax on various secondary transactions to determine whether it will increase or decrease efficiency.

Generally, we can expect most transportation taxes to fall on the final users of transportation services. Gasoline taxes will fall mostly on drivers, since supply is highly elastic while demand is inelastic. Diesel taxes and other taxes on heavy vehicles (tire taxes, weight associated taxes) will fall on truckers, but since they are spread among all goods transported it will usually end up as a tax on final consumers, except where trucks are in close competition with railroads. In this case truck taxes will have to be absorbed by trucking firms, lowering profits and probably driving some firms out of business, which though a personal hardship, is not necessarily a social cost. Any change in the existing economic environment, including those that increase overall efficiency, will create winners and losers. The decision to compensate losers for changes in highway taxes is a social/political choice. Property taxes usually fall on renters and homeowners, not landlords. However impact fees will be paid out of the capitalized economic rents of land, since if these rents did not exist (or were at least expected), developers would choose other sites.

Income Redistribution

An often contentious point in tax policy is the impact on income redistribution of various taxes. The two taxes that will have the most effect on income are the gasoline tax and a potential congestion tax. Registration fees and sales taxes on automobiles can have significant impacts depending how they are structured. The two keys to the impact of fees are the income elasticity of transportation demand and the ability to substitute other transportation goods for the taxed service. It is generally thought that transportation services (except possibly aviation) are income inelastic, that is, money spent on transportation increases at a slower rate than income.

Tax incidence determines the income redistributive impacts of highway taxes, since final incidence determines who actually pays the tax and therefore suffers a loss of income. With a gasoline tax, the redistributive effects will be regressive because wealthier people now tend to drive cars that are as energy efficient as those driven by the poor. This means the total tax paid will depend on mileage driven, which increases at a much smaller rate than income. Sales taxes on automobiles will also tend to be regressive, since the cost of cars purchased tends to increase at a slower rate than income. Registration fees will often be highly regressive, since they are often independent of the value of the car. Truck taxes will tend to display the same regressive nature as sales taxes since they will act as a general value added tax, though rates will be higher on commodities and lower on high value goods.

Overall Rationale For Statewide Highway Taxation

The overall rationale for statewide highway taxation is that it should be based on the equitable division of the tax burden among three classes of beneficiaries: (1) highway users, (2) directly-served property owners, and (3) the public at large.

In analyzing various taxes in the next few chapters of this report, several criteria for evaluating alternative revenue sources are used:

1. Political or Public Acceptability
2. Revenue Potential and Stability
3. Equity
4. Economic Efficiency
5. Administrative Feasibility
6. Applicability

Political and public acceptability is a key to highway taxation since a theoretically perfect tax that cannot be implemented is of limited value from a public policy perspective. Political acceptability is a product of executive branch commitment to a tax policy and legislative compliance with the proposed program. Political acceptability is influenced by, but not concurrent with, public acceptability. Since politicians are usually attempting to satisfy two goals simultaneously, reelection and public policy formation, they presumably would prefer policies that inflict no pain. Unfortunately, since by definition taxes and fees will cause discomfort, the issue becomes whether perceived benefits are sufficient to alleviate the distress caused by the necessary economic transfer to the government. Perception is the key, as a program that increases social welfare in a subtle fashion may not be properly appreciated, while demagogic politicians can harp on "higher taxes" while refusing responsibility for the deterioration of services. Thus a tax must be not only perceived as "fair," but the public must be educated with regard to the need for the services to be provided.

While marshaling public approval is necessary to create an atmosphere in which rational tax structures and investment decisions can be produced, the fact is the public is unlikely to become passionate over highway programs in general. It is special interests who will organize and focus resources to support or oppose highway taxes and programs, excluding exceptional circumstances, such as major gridlock episodes or scandal. Environmental groups will tend to oppose any program (and their financing) that increases driving or encourages development in environmentally sensitive areas. Truckers will oppose any changes that increase their costs but will support programs that allow easier access to customers. Railroads will support any change that increases costs for long-haul trucks. Urban leaders will support development programs to alleviate congestion, but will be wary of association with higher taxes or congestion tolls. Farmer groups will support maintenance of the existing rural road system, but may not be as supportive of the increased revenue required to maintain marginal roads. Automobile associations support better roads but tend to be less enthusiastic concerning gasoline taxes, preferring to shift the costs to truckers.

Political resistance to taxation encourages politicians to cut funding for expenditures such as highway maintenance since road deterioration is not easily observed, while road construction provides political benefits. One way to avoid this temptation is to set highway revenue at the level required to maintain an optimal level of investment in both construction and maintenance, and raise the required revenues through dedicated taxation. The political advantage of a system of user fees is that they tax the recipients of the service, who are more likely to accept the fiscal burden since they are the beneficiaries of the expenditures. This is one reason for earmarking highway taxes; since most citizens drive if they can be assured that increases in highway taxes will be spent so as to increase received benefits, they will find these taxes more acceptable. A key in building support for user fees is to provide assurance that the funds are efficiently employed, in the sense of cost minimization of operations and in the rational choice of projects to be funded.

Revenue potential and stability are important aspects of a tax system for both political and efficiency reasons. When revenues vary from year to year, and the highway agency lacks borrowing ability to even out expenditures, projects can often be delayed or stretched-out, increasing total costs or delaying production of benefits. Each potential tax will differ in the amount that can be collected, variability of revenues from year to year, the possibility of diversion to the general fund, sensitivity to inflation and the potential reemergence of OPEC as a factor in world oil markets.

For example gasoline taxes can vary with changes in economic activity, oil and thus gasoline prices, and more efficient engine technologies in new cars as they replace older automobiles. Automobile excise taxes will vary with personal income, while truck oriented taxes may vary with economic activity and oil prices. Sharp increases in oil prices, by both driving up the price of transportation fuels and their adverse macroeconomic impacts on the economy will lower transportation tax revenues. Use of an ad valorem tax would avoid precipitous declines in tax revenue during rapid price escalation, but cause revenue collection to decline with the price of oil. The ad valorem tax would also increase the variance of revenues collected (price tends to change more than quantity sold for transportation fuels), but it would respond to inflation without requiring action by the legislature. Registration fees tend to be more stable but less equitable, and have less potential for raising large amounts of revenue.

Equity and efficiency issues have been discussed separately because they are the most complex aspects of a tax system. Taxes vary with respect to vertical and horizontal equity, distributional impacts and their effect on economic efficiency. Since there are numerous distortions in the economy, and any tax passed by the legislature will be constrained in its structure by political constraints, second and third-best considerations will be important in evaluating various revenue raising options.

Administrative ease is important in evaluating the use of a potential tax. Economists usually ignore real world transaction costs, but these can often be larger than the deadweight losses associated with a tax. Losses include the cost to the agency of administering the tax or fee, the compliance burden on the taxpayers, and the expense of enforcing the tax and preventing evasion. Evasion prevention is important not only to maximize revenue collection but for reasons of equity. However, one serious complication that can occur is when various competing industry groups have different costs of compliance or potential for evasion, raises the possibility that the tax will put certain businesses at a competitive disadvantage.

Applicability refers to the appropriateness of a revenue source in the context of the taxpayers and beneficiaries. One aspect is the determination of the level of government responsible for collecting and spending the revenues and how the revenues are to be allocated. There are three sources of revenue— Federal, State and local, and a proper evaluation of taxes and fees requires consideration of the interaction of these government bodies. There is also the question of restrictions of the use of funds, for example, legal restrictions on the use of impact fees. If revenues are earmarked, will it be on a shared basis between levels of government, dedicated to the entire system, specific construction projects or available for maintenance? If we are to consider an entire transportation system some consideration must be given to coordination of activities between highway authorities and toll roads, mass transit systems and aviation. Who is responsible for roads between airports and highways and how should they be paid for? Given the complexity of the problems faced by an urban area like Houston, dealing with congestion, the possibility of regulation by the Environmental Protection Agency, and various layers of Federal, State, and local highways, toll roads and mass transit, decisions on funding and spending cannot be made in isolation.

CHAPTER V. CONGESTION TAXES AND ROAD CHARGES

Costs of Congestion

Traffic congestion has become a major problem in urban areas, with the FHWA estimating that the proportion of urban freeways that are congested during peak travel hours has risen from 41% in 1975 to 54 percent in 1983 to 65 percent in 1988. If no improvements are made, congestion will increase by 8.8% a year. Some areas have reached the point where delays can occur throughout the day, especially Houston, Los Angeles, and New York.[66]

The primary cause of this increase in congestion has been the shift toward driving in American households over the last few decades. Between 1960 and 1980 the number of vehicles per household grew from 1.03 to 1.61, and between 1970 and 1988 cars in use grew from 80.4 million to 121.5 million.[67] The increase in heavy truck traffic has also been a contributing factor, especially because there has also been a concurrent increase in truck accident rates. This increased traffic is basically driving over a static road system, as the number of new highway miles increased by only 9 percent between 1960 and 1987.[68] Trends toward suburban development and women in the workforce have also increased driving and made it harder for workers to choose residential locations to minimize commuting. In Texas rapid growth has also led to increased congestion as Houston and Dallas were the second and third fastest growing metropolitan areas during the 1970s and 1980s in terms of total population added.

The capacity of a facility is defined as the maximum hourly rate at which vehicles can reasonably be expected to traverse a uniform section of roadway during a given period of time, usually expressed as vehicles per hour, with 2000 vehicles per hour per lane considered the average capacity of a freeway section under ideal conditions. At this density average speed declines from 60 to 30 mph. Differing definitions of congestion are used in analysis, with the FHWA using an average speed of 54 mph and average daily traffic (ADT) of 15,000 as an indicator of approaching congestion (V/C = .77), while the city of Los Angeles uses an average travel speed of 35 mph as an indicator of significant congestion. The TTI study of roadway congestion uses the daily traffic volume threshold of 15,000 vehicles per lane for expressways, which produces delays greater than the FHWA speed, but the two measures tend to converge with increasing congestion, as shown in Table 5-1. The TTI numbers were derived in house and from a Houston-Galveston study making them particularly applicable to Texas conditions.

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[66] Lindley, Jeffrey, *Urban Freeway Congestion: Quantification of the Problem and Effectiveness of Potential Solutions, ITE Journal*, Jan. 1987 and GAO, *Traffic Congestion: Trends, Measures, and Effects*, Washington, D.C.: General Accounting Office, November 1989.

[67] GAO, 1989 and Bureau of the Census, *Statistical Abstract of the United States 1990*, Washington, D.C: US GPO, 1990.

[68] GAO, 1989.

Table 5-1. Congestion, Speed, and Average Daily Traffic (ADT) Relationships

Expressway Congestion	ADT/lane	Speed (mph) TTI	Speed (mph) FHWA
None	13,000 - 15,000		54 - 57
Moderate	15,000 - 17,500	40	45 - 54
Heavy	17,500 - 20,000	35	30 - 45
Severe	> 20,000	32	<30

Source: Hanks, J. and T. Lomax, *Roadway Congestion in Major Urban Areas 1982 to 1988*, Texas Transportation Institute, Research Report 1131-3, July 1990 and GAO 1989.

The number one congested city according to the Urban Freeway Delay Model in 1984 was Houston, with Dallas ranked 12th and San Antonio 18th of 37 urban areas with population at least one million. The definition of congestion has little impact on the model's measurement of congestion, as most serious delay occurs when volume/capacity ratios exceed 1.0 and speeds fall below 30 mph.[69] The TTI study found that Los Angeles was the most congested city in terms of total hours of delay with New York second, but Washington had the highest congestion cost per vehicle, followed by San Bernardino, New York and LA. Using a combination of freeway and major arterial traffic data Hanks and Lomax calculated a Roadway Congestion Index (RCI) values for 50 urban areas, based on daily vehicle-miles of travel on roads under congested conditions.[70] Table 5-2 presents data on the 10 most congested cities in the US. Note that Houston is the only Texas city to make the list, tied with New Orleans at tenth. However, this is a product of the economic crash in Texas that allowed highway construction to catch up to traffic. Houston peaked with a RCI of 1.25 in 1984, which made it the third most congested city that year, but congestion has steadily declined since that time.

Table 5-3 provides RCI data for seven Texas cities. Most Texas cities are relativelyuncongested, at least relative to the nation's largest metropolitan areas. Those cities such as Austin, Dallas, Fort Worth and San Antonio, that were approaching congested status in the mid-1980s found their streets less crowded as the economic decline provided time for transportation construction to match demand. However once economic recovery returns to the state one would expect congestion to resume its upward trend unless there is a commitment to highway expansion and driver diversion.

[69] Lindley, 1987, and GAO, 1989.

[70] Hanks, J. and T. Lomax, *Roadway Congestion in Major Urban Areas 1982 to 1988*, Texas Transportation Institute, Research Report 1131-3, July 1990.

Table 5-2. Selected Roadway Congestion Index Values 1982 to 1989

	Year								Percent change
	1982	1983	1984	1985	1986	1987	1988	1989	1982 to 1989
National Urban	0.86	0.88	0.90	0.92	0.95	0.97	0.98	0.99	
Los Angeles	1.22	1.27	1.36	1.47	1.54	1.32	1.42	1.52	26
SF/Oakland	1.01	1.05	1.12	1.17	1.24	1.31	1.33	1.36	35
Washington	1.07	1.09	1.20	1.12	1.28	1.30	1.32	1.36	27
Miami	1.05	1.09	1.07	1.13	1.10	1.14	1.18	1.25	19
Chicago	1.02	1.02	1.05	1.08	1.15	1.15	1.18	1.21	19
Seattle-Everett	0.95	0.99	1.02	1.05	1.09	1.14	1.17	1.21	27
San Diego	0.78	0.84	0.91	0.95	1.00	1.08	1.13	1.18	51
San Bernardino	1.09	1.11	1.12	1.11	1.14	1.13	1.16	1.16	6
Atlanta	0.89	0.94	0.97	1.02	1.09	1.15	1.10	1.14	28
Houston	1.17	1.21	1.25	1.23	1.21	1.19	1.15	1.13	-3

Source: Hanks, J. and T. Lomax, *1990 Roadway Congestion Estimates and Trends*, Texas Transportation Institute, Research Report 1131-4, July 1992.

Table 5-3. Texas Roadway Congestion Index Values 1982 to 1989

	Year								Percent change
	1982	1983	1984	1985	1986	1987	1988	1989	1982 to 1989
National Urban	0.86	0.88	0.90	0.92	0.95	0.97	0.98	0.99	
Texas Urban	0.80	0.84	0.86	0.89	0.92	0.90	0.90	0.90	
Corpus Christi	0.67	0.69	0.69	0.71	0.71	0.72	0.70	0.71	6
El Paso	0.63	0.64	0.65	0.70	0.75	0.71	0.74	0.74	17
San Antonio	0.77	0.79	0.82	0.87	0.90	0.85	0.86	0.87	11
Fort Worth	0.76	0.79	0.82	0.87	0.90	0.85	0.86	0.87	13
Austin	0.77	0.84	0.89	0.91	0.98	0.96	0.96	0.96	25
Dallas	0.84	0.89	0.94	0.98	1.04	1.02	1.02	1.02	21
Houston	1.17	1.21	1.25	1.23	1.21	1.19	1.15	1.13	-3

Source: Hanks, J. and T. Lomax, *1990 Roadway Congestion Estimates and Trends*, Texas Transportation Institute, Research Report 1131-4, July 1992.

The FHWA estimates that total delay due to congestion in 1984 amounted to 1.252 billion vehicle hours (valued at $7.50/hr), resulted in excess fuel consumption of 1.4 billion gallons of gasoline, and cost almost $11 billion (1990$) dollars. The effects of congestion include direct costs to individuals in terms of increasing personal travel time and vehicle operating costs, estimated at $135 in lost time and $97 in fuel and maintenance by the California study, and $278 for delay ($8.80/hr in 1988$) and $44 for fuel in the TTI study. The TTI study also included higher insurance premiums of $100 per vehicle as the third major congestion related cost, due to higher accident rates associated with driving in congested traffic. An indirect cost that is hard to quantify is the degradation of the quality of travel. Costs nationally ranged from $920 per registered vehicle in Washington D.C. to as low as $40 for Corpus Christi. Table 5-4 gives the estimated economic impact of congestion in Texas in 1988 and Table 5-5 provides trends in congestion costs for Texas cities.

Despite the fact that congestion in Texas cities other than Houston is not at extreme levels, there are still substantial economic costs, especially for drivers in Houston and Dallas, and to a lesser extent in Austin and Fort Worth. Surprisingly, despite a lower RCI value congestion costs in Dallas are almost equal to those in Houston, as costs depend on the quantity of time lost, not the extent of congestion. These dollar figures should be treated with a certain degree of skepticism, since they depend on the value of time (Hanks and Lomax use a value that's about 25% above FHWA). On the other hand congestion delays due to diversion of traffic to secondary roads are not included, which probably underestimates costs in highly congested cities.

Congestion can also generate macroeconomic costs because it limits the growth of dynamic production networks based on the "just in time" integration of spatially distant producers. Businesses suffer additional costs due to longer trips made by employees during business hours and sub optimal business use. Costs to the trucking industry due to freeway delays range between $4.2 and $7.6 billion annually, with losses on urban streets double or triple this figure.[71] Congestion adds to pollution since carbon monoxide and hydrocarbon emissions are higher at slower speeds, particularly below 40 mph, and higher when vehicles are accelerating or decelerating or idling. However, the TTI study did not find any correlation with the level of congestion and ozone levels.

Empirical Estimates of Congestion Tolls

There have been numerous attempts by economists to calculate the level of optimal congestion tolls. Mohring found an optimal toll of 35-75¢/mile (all prices in 1990$) for volume/capacity ratios between .7 and .9 (assuming the value of time at $6.80/hr) and a single period toll of 4-5¢/mile.[72] Walters found a range from 10¢/mile for urban roads under average

[71] GAO, 1989

[72] Mohring, Herbert, "Relation Between Optimum Congestion Tolls and Present Highway User Charges," *Highway Research Record* N47, TRB, National Research Council, Washington D.C., 1964, p. 1-14.

Table 5-4. Estimated Economic Impact of Congestion in Texas in 1988

City	Cost per Registered Vehicle		Cost per Capita	
	Total Cost	Delay and Fuel	Total Cost	Delay and Fuel
Austin	320	300	320	290
Corpus Christi	60	40	50	30
Dallas	600	500	490	410
El Paso	150	90	100	60
Fort Worth	370	290	330	260
Houston	660	520	520	410
San Antonio	280	210	220	160

Source: Hanks, J. and T. Lomax, *Roadway Congestion in Major Urban Areas 1982 to 1988*, Texas Transportation Institute, Research Report 1131-3, July 1990.

Table 5-5. Trends in Congestion Costs in Texas ($ per vehicle)

	Year			
	1986	1987	1988	1989
National Urban	340	380	400	440
Texas Urban	340	320	330	360
Houston	680	580	620	690
Dallas	560	550	580	660
Fort Worth	360	330	340	380
Austin	390	350	330	370
San Antonio	280	280	250	270
El Paso	110	90	100	90
Corpus Christi	40	50	50	50

Source: Hanks, J. and T. Lomax, *1990 Roadway Congestion Estimates and Trends*, Texas Transportation Institute, Research Report 1131-4, July 1992.

conditions to 68¢/mile for peak periods.[73] Kraus, Mohring and Pinfold estimate a cost of 10-31¢/mile for suburban roads and 17-52¢/mile for urban roads in the Twin-Cities area.[74] Keeler and Small provide a range of 5-17¢/mile for rural roads, 5-23¢/mile on suburban roads, and 15-88¢/mile on central city highways, compared to 0.4-2¢/mile for pollution costs, and 3.7¢/mile user costs in the Bay area.[75] Small estimates a toll of 47¢/minute of delay that when applied to heavily congested roads on a per mile basis (a decline in speed from 60 to 30 mph adds a minute per mile) gives 47¢/mile.[76] Lee provides a value of 11-24¢/mile for noninterstate highways with volume/capacity ratios of .75 to .95.[77]

The general consensus seems to be that uncrowded rural roads should have a fee around 1-5¢/mile, 10¢-30¢/mile for suburban roads, and 35¢/mile for urban roads rising to close to 70-90¢/mile during rush hour. Obviously, this would be an extremely complex set of tolls to establish, especially in light of Dewees' finding that an accurate simulation of traffic flows would result in an even wider range of optimal tolls. DeCorla-Souza and Fleet estimate that new facilities could be finance by a 23¢/mile single period charge in the core of urban areas, and 10¢/mile on the fringe while peak users could be charged 22-53¢/mile if equity was desired.[78] Given that an exact congestion toll could not be determined, and if calculable, would be difficult to administer under present circumstances, there is still a role for a fee that at least approximates this optimal toll.

The value of a fee that institutes a charge for congestion would be two-fold; it would provide funds for capacity expansion or mass transit while also increasing incentives to reduce driving. Ideally it would be instituted as a peak period fee if the institutional barriers against such a program could be overcome, but even a single period fee in congested regions would have benefits. Houston is the most obvious area to institute such a fee, followed by Dallas, Fort Worth and Austin. To obtain political support it probably should be earmarked for use only in the regions collected, divided between local transit needs and improvements to state highways. Since it would not increase costs to rural districts, they should have no reason to oppose such special taxing authorities, while drivers in urban areas should, given a properly run campaign to explain the benefits, be amenable to a 5-10 cent gasoline tax that would help relieve

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[73] Walters, A.A., "The Theory and Measurement of Private and Social Cost of Highway Congestion," *Econometrica*, 29(4), Oct. 1961, p. 676-699.

[74] Kraus, M., H. Mohring, and T. Pinfold, "The Welfare Costs of Nonoptimum Pricing and Investment Policies for Freeway Transportation," *American Economic Review*, 66, Sept. 1976, p. 532-547.

[75] Keeler, T. and K. Small, "Optimal Peak-Load Pricing, Investment, and Service Levels on Urban Expressways," *Journal of Political Economy*, 85(1), 1977, p. 1-25.

[76] Small, Kenneth, "The Incidence of Congestion Tolls on Urban Highways," *Journal of Urban Economics*, 13, 1983, p. 90-111.

[77] Lee, Douglas, "Net Benefits From Efficient Highway User Charges," *Transportation Research Record* N858, TRB, National Research Council, Washington D.C., 1982, p. 14-20.

[78] DeCorla-Souza, P. and C. Fleet, "Increasing the Capacity of Urban Highways: The Role of Freeways," *Transportation Research Record* N1283, TRB, National Research Council, Washington D.C., 1990, p. 22-33.

congestion. While well below the optimal level (10¢/mile would be around $2/gallon), it would at least be a step in the right direction.

Congestion Pricing in Practice

The federal government has been interested in experimenting with road pricing since the mid-1970s. In 1976 the Secretary of Transportation offered funds and the services of the Urban Institute to cities thought to be willing to support such a scheme, such as Berkeley and Madison, as well as more congested urban areas like Baltimore and Atlanta. In Berkeley the proposal was attacked on the grounds that road prices infringed upon the "freedom of the road" after a reporter for the San Francisco Chronicle reported that there were plans to charge a fee for daily use of the roads. The public perception that pricing would apply to all places at all times doomed road pricing despite the focus of the study on reducing rush hour traffic and supporting public transit. In Madison reasons for rejection included the perception that the fee would be regressive, appear to be coercive, and that it may hurt local businesses. Other objections included the perception that it would be hard to enforce, would overload transit facilities, and would relocate traffic problems through spillover on streets not priced. There were also questions of legality, enforcement and technical feasibility.[79]

In the mid-1970s a Task Force of economic, engineering and environmental planners, working for the California State Transportation Board, was established to study the state's transportation problems, eventually spending $50 million. The economists attempted to institute 'full social accounting' of transportation alternatives, including time and pollution costs, and user charges proportional to benefit received. The report was hailed by economists, environmentalists and civic groups and castigated by road and transport interests. The State Transportation Board responded to interest group pressure, eliminating language referring to economic accountability, and substituted calls for more regulation and 'partnership' between public and private sectors. The element in the report that instigated the most virulent attacks was the suggestion of congestion pricing.[80]

The California Chamber of Commerce combined with several automobile clubs to attack time and location specific charges to reduce congestion, including experimental schemes on freeways. It was suggested that the inner urban areas would suffer from increased competition from suburban merchants. Motoring lobbies fought for the right to make 'free use' of the highways, environmentalists saw road pricing as 'licenses to pollute,' others saw it as either futile or an exercise in social engineering. One reason for strong opposition was the inability of supporters to offer a well documented case for road pricing, leaving opponents with the impression that the choice was between road pricing and the status quo, not a more congested

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[79] Button, Kenneth, "Road Pricing--An Outsider's View of American Experiences," *Transport Reviews*, 4(1), 1984, p. 73-98 and Higgins, Thomas, "Road-Pricing Attempts in the United States," *Transportation Research*, 20A(2), 1986, p. 145-150.

[80] Higgins, 1986

future. The media also missed many of the subtle trade-offs between revenues from user charges and lowering other taxes used for building roads.[81]

The public appears least resistant to road pricing when it is presented as a user fee to support roads, replacing current taxes. There is some evidence that opinions are changing in Southern California for two reasons, the dramatic current and projected increase in congestion and the threat of severe actions by the Environmental Protection Agency if air pollution problems, partially automobile related, are not addressed. The Auto Club of Southern California, the California Trucking Association and economists within the Southern California Association of Governments are beginning to see some sort of congestion charge as a possible solution.[82]

Attempts have also been made to institute road pricing on bridges, since administration is obviously far simpler than on a freeway or general road system. In San Francisco an attempt was made to include peak load charges with a general increase in fees on the Bay Areas Metropolitan Transportation Commission bridges. Strong local protest kept the peak toll at 75¢ instead of a dollar, due to the opposition of commuters traveling from the East Bay who had no high quality public transport option. Similar proposals were rejected for the Golden Gate bridge, partially on equity grounds, because it was felt that road pricing was inappropriate on facilities supported by user taxes and public funds. Also, the low traffic elasticities of tolls because of the high cost of parking in San Francisco make them inefficient as a traffic reduction method. The New York Port Authority discontinued commuter discounts and began a carpool discount, similar to San Francisco bridges.[83]

The major experiment in road pricing occurred in Hong Kong. Initially the Hong Kong government responded to increased congestion by doubling initial registration fees, tripling license fees and increasing the gasoline tax from 30¢ to 68¢ per gallon, dramatically reducing car ownership for four years before it resumed its upward growth. In the Cross-Harbour tunnel, fares were increased from $.67 to $1.33, reducing tunnel traffic by 10%. In 1983 the Hong Kong government began a two-year electronic road pricing experiment with 2,600 cars, each fitted with an electronic number plate, to be read by 18 sensing loops buried under the road surface. Closed circuit camera were installed to photograph cars that passed over sensors without registering. In 1985 the Transport Branch of the Government of Hong Kong presented a true marginal cost pricing scheme, using electronic road pricing. The tests found that 99.7% of all vehicle crossings were accurately recorded and the roadside computers worked more than 99% of the time, and the camera had no difficulty identifying automobiles.[84]

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[81] Button, 1984.

[82] Higgins, 1986.

[83] Button, 1984.

[84] Borins, Sanford, "Electronic Road Pricing: An Idea Whose Time May Never Come," *Transportation Research*, 22A (1), 1988, p. 37-44 and Hau, Timothy, "Electronic Road Pricing: Developments in Hong Kong 1983-1989," *Journal of Transport Economics and Policy*, 24(2), May 1990, p. 203-214.

The government published a brief on road pricing in June 1985 for public consultation. Two alternatives were presented— either intensify the car ownership restraints or install electronic road pricing, rejecting fuel taxes as ineffective and parking controls and area licensing as too costly to administer. Models suggested that road pricing for private cars would reduce peak-period traffic by about 20%, shifting it to off-period. Road pricing would be more costly to administer and produce less revenue than continuing licensing taxes, but would be both more equitable and more efficient. The capital cost of installing the system was placed at $30 million with annual operating costs of $2.5 million.[85] Net benefits of the three road pricing schemes were estimated at $94 -118 million (1985$) compared to $39 million from car ownership restraints. The transfer to the government would also be smaller, $50 - 70 million for road pricing against $154 million for restraints. The average peak charge would be around $1 per vehicle.[86]

Initially electronic road pricing had two opponents: the Hong Kong Automobile Association and the chairman of a Mercedes-Benz importer. Exemptions for taxis, commercial vehicles and buses increased the proposed rate on private automobiles, fueling opposition. One of the major issues was invasion of privacy, not surprising given the pending takeover by communist China. Other factors leading to rejection included the feeling that congestion had declined, allowing postponement of electronic pricing, and a lack of confidence in the government, both in terms of the validity of projections and regarding the promise of using the revenues to reduce other road costs.[87] A fundamental problem with installation of electronic pricing is that to overcome opposition, congestion must rise to the point where people will accept any palliative. Electronic road pricing would take years to put in place, encouraging other forms of traffic restraint, which if successful, would alleviate congestion and decrease support for road pricing.

Despite the failure to institute electronic road pricing in Hong Kong, other municipalities are planning to apply congestion tolls and/or electronic road pricing. Bergen and Oslo in Norway are converting their existing toll rings around the CBDs to electronic toll collection (though without peak period pricing). The Dutch government plans to install electronic road pricing in Amsterdam, Rotterdam, Utrecht, and the Hague as part of its environmental policy plan. Singapore plans to convert its sticker based pricing system to congestion tolls. In the United Kingdom, Cambridge and Edinburgh are also planning to establish congestion pricing.[88]

The tests in Hong Kong and the general improvement in equipment have made it clear that there are no technical barriers to installation of a road pricing system. Optical scanners, radio frequency or other technologies to identify drivers would theoretically allow design of a

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[85] Broins, 1988

[86] Hau, 1990.

[87] Borins, 1988, Hau, 1990.

[88] Poole, Robert, "Introducing Congestion Pricing on a New Toll Road," *Transportation Research Board, 71st Annual Meeting*, Jan. 1992, preprint.

system that could charge for use of roads by location and time of day. Varying rates could be charged and automatic billing employed, similar to present billing for electrical services. One advantage of a road pricing system would be the availability of accurate information concerning road use, allowing optimization of both traffic control systems and traffic planning. Currently there are plans to install a pilot project in Orlando, Florida called TravTrek. TravTrek will provide traffic information, motorist services information and route guidance to operators of one hundred test vehicles.[89] Combining motorist services with a congestion pricing system would certainly make it more acceptable to the public.

The key to eventual installation of road pricing will be in creating the political atmosphere where it will receive serious consideration. Economists often focus on net benefits of such a system. However, note that user benefit is always reduced (unless the time value of the driver is high, which raises distributional questions, and perception of benefit is still a problem), even though society benefits. In order to build support, the benefits to be received must be clearly elucidated, which in turn depends on the use of the revenues. There are three major options: use revenues to increase road infrastructure, return revenues to road users, or apply road revenues to alternatives to road transport.

Using revenues from road pricing to increase road infrastructure makes sense from equity and efficiency viewpoints. The reason to tax drivers during peak periods is to compensate for the externality they impose upon other drivers; but this externality in turn is a function of the capacity of the road system. Therefore earmarking the funds to improve the roads from which they are collected in effect returns the tax to those paying it, the users of those roads. It is efficient since the existence of a congestion externality is a signal that the road system is under built, and therefore, additional capacity should be added. There are some limitations to this approach; increasing capacity lowers the cost of driving, which will increase the quantity of other externalities if proper charges are not made, specifically pollution and national security impacts of increased gasoline consumption. Many urban freeways will be extremely expensive on the margin to expand, so that it would be wasteful to expend all the revenue collected in the area on the specific roads from which fees are collected. Increased traffic will acerbate traffic and parking problems in the urban center.

Returning revenues to road users could be easily performed by simply requiring other user fees to be reduced by the net revenues from road pricing. Since congestion tolls are more efficient and more equitable than most user fees, this would be a net improvement. One problem is that current expenditures are determined and allocated by a political process; replacing general user fees with congestion tolls could result in a situation where funds are collected from congested urban areas but used to lower costs on trucks and rural drives, or spent on non urban facilities. Separating revenue collection from spending would also allow planers to ignore the signals provided by congestion tolls to expand capacity in certain regions.

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[89] Edelstein, R. and M. Srkal, "Congestion Pricing," *ITE Journal*, 61, Feb. 1991, p. 15-18.

Within the urban areas where congestion tolls will be highest there are some good arguments for using some funds for mass transit, from both economic efficiency and social welfare. Since the purpose of congestion tolls is to lower congestion, one means is to provide adequate substitutes for driving. As most mass transit systems exhibit decreasing costs, subsidization would be both economically efficient and help to lower congestion by increasing the elasticity of substitution between driving and mass transit. The most likely drivers to be driven off the road, and those with the lowest benefits, will be the ones with the lowest value of time. In general these are also the people who benefit most from affordable, safe, mass transit. This is especially true in urban areas with a large proportion of low income drivers.

This raises the question of the impact of road pricing on income distribution. Discussions of the topic have focused on whether the potential Pareto-improvement would actually result in the gainers compensating the losers. Since the value of time increases with income, substantial net benefits for higher income drivers is assumed by all commentators.[90] However, for drivers with lower incomes the effect may be regressive if journeys are a necessity. For example, commuters who have limited alternatives to driving for whom the tax exceeds the gain in the value of time. There is also the group of poorer drivers who are forced off the road and lose the benefit of driving.[91] Therefore it may be important to target revenues to compensate for the distributional effects of congestion pricing.

One possible strategy for moving to road pricing would be to start with toll roads and bridges, where the principle of paying to drive has already been established. New toll roads would be ideal experiments, since all users would be new to the road and have no basis for complaints concerning peak hour pricing. Existing toll roads would still be good candidates for demonstration projects, both because some sort of electronic priced lanes would make toll collection easier and because there are usually alternatives to the road for drivers who object to peak load prices. Houston as the most congested city in Texas and also the city with the most stringent requirements under the Clean Air Act, is perhaps the obvious choice for a demonstration project to examine the feasibility of the concept and to test technologies and efficacy.

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[90] Richardson, Harry, "A Note on the Distributional Effects of Road Pricing," *Journal of Transport Economics and Policy*, 8, 1974, p. 82-85, Foster, "A Note on the Distributional Effects of Road Pricing: a Comment," and Richardson, "A Rejoinder," *Journal of Transport Economics and Policy*, 9, 1975, p. 186-188.

[91] Layard, "The Distributional Effects of Congestion Taxes," *Economica*, 44, 1977, p. 297-304 and Cohen, Yuval, "Commuter Welfare Under Peak-Period Congestion Tolls: Who Gains and Who Loses?" *International Journal of Transport Economics*, 14, Oct. 1987, p. 239-266.

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CHAPTER VI. WEIGHT DISTANCE TAXES

Cost Allocation and Truck Burden

The basic logic for a weight-distance tax stems from the cost responsibility of trucks for maintenance and road replacement costs and the desire for horizontal and vertical equity. The two key issues are that damage is related to weight per axle and the design of the road upon which the vehicle travels. Any weight-distance tax in which the rates are expressed in terms of gross vehicle weight tends to ignore differences in terms of equivalent single axle loads. The reason this is important is that road damage has traditionally been associated with the fourth power rule (damage = $[\text{axle weight}/18{,}000]^4$), so that most studies of road damage costs use 18-KIP Equivalent Single Axle Loads (ESALs), an axle loading that would cause the same damage as an 18,000 lb. per axle load, as the unit of vehicle loading. ESAL ratings depend both on the weight per axle and the axle configuration, as tandem axles can carry more total weight than single axles for the same ESAL rating. The standard five-axle tractor-semitrailer combination (3-S2) carrying 80,000 lb. would be assigned a total of 2.45 ESALs, for example. The ideal solution would be to replace gross weight taxes with ESAL equivalent based taxes, since with microcomputers it is simple to calculate ESALs given the weight and axle configuration of a truck.[92]

There have been a number of recent studies of the costs associated with heavy vehicles. The state of Indiana in 1984 developed a model that estimated pavement routine maintenance, in which average daily traffic values were converted to ESALs. The best cost model for reinforced concrete pavement sections was:

$$\log(\text{Cost}) = 0.005(\text{Age}) + 0.54\log[\text{ESAL}]$$

The best cost model for resurfaced concrete pavement sections was:

$$\log(\text{Cost}) = 0.032(\text{Age}) + 0.57\log[\text{ESAL}]$$[93]

A proposed scheme for Indiana to match revenue contributions to cost responsibility assigned a weight distance tax ranging between 1¢/mile on trucks weighing 48-54,000 lb. to 8.5¢/mile on trucks weighing 78,000 lb. and above.[94]

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[92] Merriss, J. and M. Krukar, "A Proposal for an Axle Weight-Distance Road User Charge," *Transportation Research Forum*, 23(1), 1982, p. 405-411.

[93] Gibby, R., R. Kitamura, and H. Zhao, "Evaluation of Truck Impacts on Pavement Maintenance Costs," *Transportation Research Record* N1262, TRB, National Research Council, Washington D.C., 1990, p. 48-56.

[94] Sinha, K., T. Fwa, and H. Michael, "Highway Cost Allocation and User Tax Revision in Indiana," *Transportation Research Record* N1077, TRB, National Research Council, Washington D.C., 1986, p. 18-27.

Gibby, Kitamura and Zho used data obtained from Caltrans to estimate cost responsibilities of various road users. They determined that on a typical roadway section each additional heavy truck (defined as trucks with five or more axles) per day costs $3.73 in maintenance per mile per year, compared to 4¢ for each light truck or car, and the average annual maintenance cost per vehicle is $7.60/mile for trucks and 8¢/mile for cars (assuming 988 trucks and 23,700 cars per day). They tested for the effect of age and weather, and found that road age had only a minor effect, and weather impacts were minimal.[95]

Vitaliano and Held estimated an economic model of pavement-damage costs for New York state. Their model takes in account the timing of maintenance in attributing costs to vehicle, as the relevant marginal damage cost is the ESAL-attributable fraction of damage multiplied by the change in annualized overlay cost. Since the time to maintenance is a major factor in these models, choice of discount rate becomes important. The authors use a 0.05 real interest rate as compared to the 0.09 employed by Small and Winston, which implies a 20 percent higher charge using the lower interest rate.

The authors also attribute one-half of road damage to weather, though without empirical evidence for this assumption, while Small and Winston assume all damage is due to traffic.[96] Small, Winston and Evans in their Brookings study, Road Work, review the evidence that weather has an effect on road surfaces and conclude, at least for rigid pavements, that there is no evidence of a significant aging effect. They provide examples of freeways that are closed to trucks that have lasted 35 years without resurfacing, and find that those roads that experienced damage in Northern states could attribute this to the impact of snow tires, rarely a problem in Texas.[97]

Table 6-1 demonstrates a major problem with assigning costs to trucks, since the damage caused by a truck depends on the type of road upon which it travels. Vitaliano and Held estimate that the average cost is 7.6¢/mile, but a significant volume of loads travel on roads with costs far above or below this level. At present it would be prohibitively costly to monitor and charge trucks for the various roads they use, so horizontal inequity is inevitable when the average cost is charged. One possibility would be to limit travel on roads that are not designed for trucks, requiring a special license, allowing trucks using main arteries to avoid this additional expense and discouraging travel on alternative routes. There is some reason to believe that for the most part, using a uniform tax will not have that much of an effect on the efficiency of a weight-distance tax. Small, Winston and Evans compared a uniform tax of 3¢/ESAL-mile with a two-part tax of 0.11¢/ESAL-mile for freeways

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[95] Gibby et al. 1990

[96] Vitaliano, D. and J. Held, "Marginal Cost Road Damage User Charges," *Quarterly Review of Economics and Business*, 30(2), Summer 1990, p. 32-49 and Small, K. and C. Winston, "Optimal Highway Durability," *American Economic Association*, 78(3), June 1988, p. 560-569.

[97] Small, K., C. Winston and C. Evans, *Road Work: A New Highway Pricing and Investment Policy*, Washington D.C.: The Brooking Institution, 1989.

and 7.82¢/ESAL-mile for non freeways with a full marginal cost price scheme (see Table 6-2), and found little difference in total welfare, though the transfer from truckers to the government is larger under a uniform tax. Unfortunately their analysis assumed that their optimal road investment practices are followed; under current road building practices the uniform fee would be substantially higher.[98]

A problem with current cost allocation studies is that they assume, or at least ignore the question of optimal road design. If the re-estimation of AASHTO equations by Small and Winston is correct, (New Zealand's 1984 report on road user charges used a third-power rule similar to the Small and Winston results instead of the traditional fourth power rule for apportioning pavement wear costs.[99]), then there is a significant divergence between current damages caused by trucks and the marginal cost of these loads on optimally designed highways, as can be seen in Table 6-2.

Along with constructing roads below the optimal thickness, a second problem that may increase the maintenance cost associated with heavy loads is suboptimal construction techniques. There are few economic incentives for American highway contractors to use state-of-the-art materials since federal financing requires use of the lowest bidder. If current practices were replaced by the requirement to build roads with the lowest expected lifetime costs, combined with performance guarantees, thicker roads built with better materials would dominate high traffic arteries, significantly lowering marginal costs associated with trucks. Europeans manage to maintain highways over lifetimes double that of American roads, despite allowing higher weights per truck axle, due to superior materials and road thickness which exceed American standards.[100]

Table 6-1. ESAL Charge per Mile

Functional Road Class	Average ESAL Loading (/mile)	Per Mile Charge ($)	% EASL Loading	Per MIle Charge ($)[a]
Interstates	1,105,000	0.030	37	
Urban Expressways	529,000	0.069	8	0.370
Rural Expressways	239,000	0.064	9	0.133
Urban Arterials	174,000	0.138	9	0.977
Rural Arterials	91,000	0.106	9	0.311
Urban Collectors	81,000	0.387	14	0.95-1.184
Rural Collectors	38,000	0.742	14	0.41-0.74

Source: Vitaliano, D. and J. Held, "Marginal Cost Road Damage User Charges," *Quarterly Review of Economics and Business*, 30(2), Summer 1990, p. 32-49 and (a) *State Highway Cost-Allocation Guide*, Federal Highway October 1984, Washington: USGPO, 1984 (in 1990$).

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98 Small, Winston, and Evans 1989.

99 Gibby et al. 1990

100 Dance, Betsy, "Why Our Roads Go To Pot," *Washington Monthly*, November 1991, and Bruce Van Voorst, "Why America Has So Many Potholes," *Time*, May 4, 1992, p. 64-65.

Table 6-2. Current ESAL Maintenance Costs vs. Optimal Investment Maintenance Costs

Functional Road Class	Per Mile Charge (¢) Current Investment	Optimal Investment	Optimal Thickness (inches) Current Investment	Optimal Investment
Rural: Interstates	1.48	0.46	9.52	11.35
Rural: Other Arterial	4.38	1.13	7.79	8.67
Rural: Minor Arterial	10.02	2.60	6.5	26.59
Rural: Major Collector	16.49	9.96	2.46[f]	2.69[f]
Rural: Minor Collector	31.18	16.09	2.18[f]	2.42[f]
Urban: Interstate	2.38	0.33	10.07	13.52
Urban: Freeway	4.32	0.61	9.21	11.81
Urban: Other Arterial	10.92	0.87	7.92	10.04
Urban: Minor Arterial	33.92	3.23	6.78	7.50
Urban: Collector	125.45	13.66	2.51[f]	3.73[f]

Pavement is rigid unless noted by superscript f.
Source: Small, K., C. Winston and C. Evans, *Road Work: A New Highway Pricing and Investment Policy*, Washington D.C.: The Brooking Institution, 1989.

Existing State Weight-Distance Taxes

A number of states currently charge some form of a weight distance tax. Seven states use a registered gross vehicle weight distance tax (RGVWDT), Arizona, Arkansas, Idaho, Nevada, New Mexico, New York and Oregon. In this case the tax is imposed upon the maximum load to be carried during the tax year. Oregon allows carriers to report mileage in multiple configurations if they choose to exercise this option, since some tractors are used to pull a variety of trailers. Ohio is presently the only State with a weight-distance tax based on configuration and number of axles, but it fails to take vehicle weight into consideration.[101] The general consensus from their experience is that such a tax is feasible to impose, has acceptable administrative costs and compliance rates (see Table 6-3), and does not impose undue costs upon truckers.

[101] Federal Highway Administration, *The Feasibility of a National Weight Distance Tax*, Report of the Secretary of Transportation to the US Congress, Dec. 1988.

The Arizona weight distance tax was implemented in July 1982. A ton-mile tax was considered but considered to difficult and expensive to administer, and instead a two-part schedule was chosen. Light vehicles, between 12-26,000 lb. pay between $64 and $119 dollars. Heavier vehicles pay on a per mile basis, ranging from 1.319¢/mile for vehicles between 26-28,000 lb. to 8¢/mile for vehicles in the 75-80,000 lb. class. Exemptions to the tax include vehicles owned by the federal or Indian tribal government or operating on Indian roads, vehicles owned by state and local government, school buses, public transit and RVs. Vehicles operating with a significant ratio of "deadhead" miles can reduce their liability by 30 percent if they are run 45% or more of total miles without a load. This discount also applies to agricultural vehicles. Carriers establish tax accounts with the Motor Vehicle Division, and when a credentialed vehicle enters Arizona, port of entry officials log-in the information as well as the number of miles to be traveled and the vehicle is weighed. Other vehicles are issued a "single trip permit." An enforcement project found noncompliance by credentialed vehicles to be 7.5%, not including non-reporting or under-reporting. The estimated cost of administration of the system is 0.8 percent.[102]

The Arkansas Highway Use Equalization Tax was passed in 1983 to raise funds to match Federal Aid requirements, and to raise the weight limit from 73,280 to 80,000 lb. A tax of 5¢/mile or an annual tax of $175 is charged. Collection costs are less than 2 percent of total revenues. No additional record keeping requirements were imposed on truckers, as International Registration Plan documents or Arkansas Bonded Fuel Use reports also serve as documentation to qualify for the mileage option of the tax.[103]

The state that has made the most extensive use of weight-distance taxation has been Oregon, which has had some form of this tax dating from 1925 in the form of a ton-mile tax, first on for-hire vehicles, then extended to private carriers in 1933. A weight-mile tax was enacted in 1947. The Oregon weight-mile tax is levied on the basis of registered gross vehicle weight, ranging from 0.8¢/mile for the lightest vehicle group to 13.2¢/mile for 80,000 lb. trucks. Rates differ for gasoline powered trucks to account for the costs of the gasoline tax. Forestry and farm trucks can pay a flat fee per 100 lb. to account for empty back hauls and seasonal use. The tax is self-reported, but an extensive audit program is used for enforcement, costing about 2 percent of gross collections. The PUC staff estimates that it collects at least 95 percent of the taxes due, corroborated by comparison of collected data with estimates of truck travel obtained from 112 traffic recorder stations. The overall cost of administering the tax is estimated at 5 percent of gross collections. Where there have been some attempts to impose retaliatory taxes by neighboring states, the actual impact has been relatively minor, more symbolic than substantive in nature.[104]

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[102] Martin, Juan, "Arizona Weight-Distance Taxation" *AASHTO Quarterly*, 63(3), July 1984, p. 20-23.

[103] Cooper, Billy, "Arkansas' Experience and Perspective of Weight-Distance Taxes," *AASHTO Quarterly*, 63(3), July 1984, p. 24-25.

[104] Coulter, H. Scott, "The Oregon Weight-Distance Tax" *AASHTO Quarterly*, 63(3), July 1984, p. 28-31.

Table 6-3. Costs Of Administering State Weight-Distance Taxes

State	Total Costs (% Revenue)	Compliance Rates	Auditing Costs	Collection Costs	Enforcement Costs
Arizona	0.8	93%	0.4	0.1	0.3
Arkansas	2.8	95	0.6	2.2	negligible
Colorado	6.9	90	0.1	1.5	5.3
Idaho	5.1	84	2.4	2.6	0.1
Kentucky	4.0	80-90	2.7	1.3	in audit cost
New Mexico	3.8	90-95	0.7	1.9	1.2
New York	5.0	76-90	2.1	2.9	0.0
Ohio	4.6	90	0.8	3.9	negligible
Oregon	7.0	95	3.4	3.6	in collection
Wyoming	6.4	80-90	1.2	2.1	3.1

State	Number of Accounts	Processing Costs	Enforcement Costs	Total Cost Per Account
Arizona	24,000	$51,000	$402,000	$18.88
Arkansas	16,234	452,000	118,000	35.11
Colorado	18,300	357,000	1,326,000	91.97
Idaho	17,500	337,000	333,000	38.29
Kentucky	32,000	317,000	643,000	30.00
Nevada	13,246	N/A	N/A	N/A
New Mexico	14,000	306,000	295,000	42.93
New York	62,500	1,066,000	779,000	29.52
Oregon	35,924	2,268,000	2,117,500	121.98
Wyoming	20,000	509,000	1,045,000	77.70

Source: Lane, L. Lee, "A Railroad View of Weight-Distance Taxes," *AASHTO Quarterly*, 63(3), July 1984, p. 32-37 from Batelle "The Cost of Administering Third Structure Taxes," Columbus, Ohio: March 30, 1984, Report to the Association of American Railroads and Price Waterhouse Task A Report from Federal Highway Administration, *The Feasibility of a National Weight Distance Tax*, Report of the Secretary of Transportation to the US Congress, Dec. 1988.

Most state WDTs fail to greatly improve vertical equity because the rates are not steeply graduated, the tax is levied on vehicles without accounting for the number of axles or configuration. And most State WDT structures are capped, usually around 70-80,000 pounds. Despite these limitations the WDTs improve equity relative to registration fees because they account for miles traveled, and thus are superior in terms of horizontal equity. They do result in some improvement in vertical equity over fuel taxes because weight of the vehicle is taken into account. Because state WDTs don't charge according to axle load they fail to provide economic incentives to limit axle loading, the source of the costs produced by vehicle travel.

As can be seen from Table 6-4, a weight-distance tax does not necessarily mean that trucks will pay a large per mile fee. Both the size of the WDT and the magnitude of other fees imposed upon the vehicle are important. The only state to rely almost completely on a WDT is Oregon, with Arizona and New York imposing significant fees. However, the political will to impose a WDT seems to be correlated with a willingness to tax trucks, as all seven states rank in the top 11 in total fee per mile on a typical heavy truck. Three of the other four states surround Chicago, Indiana, Illinois and Iowa, covering the major routes across the nation. Texas ranks 44th among states, and only Michigan, among the eight major highway states (leaders in miles traveled), has lower fees on trucks.

Table 6-4. Annual State Highway Fees on a Typical 5-Axle 80,000 lb. Tractor-Semitrailer Traveling 80,000 Miles as of January 1991

State	Annual Fees	Diesel Tax	WDT	Total Cost	Cents/mile
Arizona	1,107	2,526	6,400	10,033	12.54
Arkansas	1,057	1,754	2,000	4,811	6.01
Idaho	136	2,667	3,592	6,395	7.99
Kentucky	1,260	2,695	3,200	7,155	8.94
New Mexico	132	2,386	2,534	5,052	6.32
New York	860	2,484	5,280	8,624	10.78
Oregon	320	0	10,560	10,880	13.60
Average 6 states	1,380	2,831	---	4,221	5.28
Texas	855	2,105	---	2,960	3.70

Source: TRIP, *1991 State Highway Funding Methods*, 1991.
Note: 6 states are California, Illinois, Florida, Michigan, Ohio, Pennsylvania.

Proposed Federal and State Weight-Distance Taxes

The Federal Highway Administration in its 1982 Federal Highway Cost Allocation Study recommended that the Heavy Vehicle Use Tax be modified from a tax per 1,000 lb. of gross weight to one where the tax per pound increased as weight increased, roughly reflecting the increase in damage due to greater ESAL loads. While these concerns were reflected in the STAA of 1982, with an increase in the HVUT ceiling from $240/year to $1,900/year, the Deficit Reduction Act of 1984, in response to pressure from the trucking industry, lowered the maximum limit of the HVUT to $550, compensated by a 6¢ increase to the tax on diesel fuel, thus shifting the tax burden to lighter trucks. Congress then called for the Secretary of Transportation to investigate the feasibility of a weight-distance tax for motor carriers to replace all current Federal highway user taxes, except fuel. Table 6-5 shows the 1986 federal truck tax revenues and costs from a FHWA study. Price Waterhouse evaluated the current tax structure and replacement options developed in a working paper, including a Registered Gross Vehicle WDT, a Registered Axle WDT, a Configuration-Based Gross vehicle WDT, and a two-tiered tax (HVUT and fuel).[105]

Table 6-5. Federal Truck Tax Revenues and Costs: 1986

Federal Truck Taxes	1986 Tax Revenues	Administrative Costs	Compliance Costs
HVUT	$532,792,000	2.23%	1.28-2.57%
Excise Taxes	$1,144,460,000	0.17%	0.49%
Tire Taxes	$319,545	0.10%	2.07%

Source: Federal Highway Administration, *The Feasibility of a National Weight Distance Tax*, 1988.

An RGVWDT is generally less complex than a RAWDT. Different vehicle classes are established, usually based on registered gross vehicle weight, and vehicles within each class pay the same tax rate per mile of travel. The weakness of the RGVWDT is that trucks with the same weight but different configurations cause different levels of road damage. Given the importance of configuration in determining axle loading, it may be worthwhile to accept the higher complexity of a RAWDT. Since total weight is stated at registration, adding the requirement that configuration be stated at the same time would not add significantly to compliance costs, while with modern computers it would be simple to translate into ESALs. Axle load is already calculated by truckers in complying with Federal and State bridge

[105] FHWA, 1988.

formulas.[106]

Whatever structure is chosen for a WDT, there are several factors that would tend to make administrative costs higher than current user fees. Reporting forms would be more complicated, additional computations would likely lead to more taxpayer error, and more time would be required to examine these returns for compliance, increasing processing costs. The IRS estimates that the costs for examining returns would be about 63 percent higher than the examination cost for current Federal highway user taxes, mostly due to the low current costs of administering the diesel fuel and tire taxes, as the HVUT is more expensive to administer than a WDT. Note that we are still talking a relatively small sum, about $14-20 per return annually. The additional cost for a state rather than a national WDT might be less because most states currently conduct mileage audits. Processing and examination costs might be 12% higher for a RAWDT than a RGVWDT, but collection costs would be the same.[107]

The costs to firms to collect and maintain mileage data vary substantially. Price-Waterhouse examined the costs for nine different firms. Five were small firms with 1-32 power units and an average cost of $624 per unit, with the highest value at $750. The three medium sized firms had an average of $429, and the large leasing company had a cost per unit of $216. Six of the nine firms collected mileage data for International Registration Plan (IRP) registration, and seven to report state fuel taxes, while five also used the data to monitor costs. Only the three largest carriers utilized computer support in maintaining mileage data, but two other carriers planned to automate their mileage-related information in the near future. Given that the survey was conducted in early 1987, the dramatic drop in personal computer prices should reduce the economies of scale in mileage information collection.[108]

National distribution of trucking operations are owner-operator (1 to 5 vehicles), 266,000 trucks; medium fleet (6 to 50 vehicles), 413,000 trucks; and large fleet (>51 vehicles), 690,000 trucks. According to Price Waterhouse the estimated compliance cost is $100 a vehicle for owner-operators, $223 for medium fleets, and $36 for large fleets for the RGVWDT. The cost of compliance for a RAWDT rises to $200 a vehicle for owner-operators, $287 for medium fleets and $77 for large fleets.[109] These costs should be treated with skepticism for a number of reasons. They were collected from truckers with a vested interest in overestimating compliance costs, the variance of the estimates between different carriers for compliance costs is far greater than mileage collections costs, and computerization should significantly lower compliance costs for small and medium carriers. Since most truckers collect mileage data for cost monitoring and to comply with state regulations, it should not be difficult to develop simple

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[106] FHWA, 1988.

[107] FHWA, 1988.

[108] Price Waterhouse and Co., *Study of Administrative and Compliance Procedures for a National Weight-Distance Tax*, Washington, DC: NTIS, FHWA-PL-88-031, Dec. 18, 1987.

[109] Price Waterhouse and Co., *Study of Administrative and Compliance Procedures for a National Weight-Distance Tax*, Washington, DC: NTIS, FHWA-PL-88-031, Dec. 18, 1987.

spreadsheet programs to organize data for tax compliance. The FHWA also disagreed with the Price Waterhouse conclusions, as Table 6-6 demonstrates.

The cost of compliance will depend on the weight cutoff level for trucks. Since heavier trucks cause the most road damage, and will pay the highest charges, the cost of administration and compliance will be only a small fraction of total charges. However, for lighter trucks, there may be a trade off between the increase in efficiency in their inclusion in a WDT against the increase in costs due to compliance and administration. One possibility would be to use a combination of registration fees and a differential diesel tax up to a certain weight limit, and then apply the WDT past that point. Since the goal is to improve efficiency, not achieve perfection, compromises between efficiency in charges and efficiency in collection are inevitable.

Complicating the application of a WDT are the questions of trucks traveling at various weights and traveling on toll roads. Efficiency and equity would encourage charges that relate to the actual weight of trucks rather than registered weight when feasible. Since requiring collection of this information would significantly increase overall compliance expense it would be simpler to allow truckers the option of collecting mileage by various weight configurations as in Oregon, and to receive a rebate for frequent empty back hauls. The cost of collecting this data will limit these exceptions to carriers with significant savings. The same logic applies to travel on toll roads, allowing rebates of tolls to truckers paying the WDT.

Table 6-6. FHWA Estimates of WDT Compliance Costs Per Vehicle

	Low Estimate		High Estimate	
	RGVWDT	RAWDT	RGVWDT	RAWDT
Small Carriers	$13.50	$17.96	$21.60	$47.25
Medium Carriers	9.75	12.97	15.60	34.13
Large Carriers	6.00	7.98	9.60	21.00

Source: Federal Highway Administration, *The Feasibility of a National Weight Distance Tax,* 1988.

One of the major concerns regarding a WDT is the potential for evasion. As the HVUT program demonstrated, a significant increase in compliance can be ensured through a proof-of-payment program, required for vehicle registration. The first year after the HVUT proof-of-payment program the number of returns increased by 21 percent and revenues by 45 percent.[110] While this would be more difficult to implement for an individual state, given that 37 states are

[110] FHWA Study, 1988.

already members of the IRP it would not be an insurmountable obstacle. Since mileage records are already kept with the state, these should make identification of probable violators a simple procedure. Given that similar problems exist with enforcement of state fuel tax and IRP regulations, there is no reason to believe that evasion will be more prevalent or more expensive to detect. In fact, referring to Table 6-3, compliance rates for existing weight-distance taxes are around 90%, similar to other state highway user taxes.

One factor that will make enforcement easier in the future is the rapid advancement of technology to monitor truck movements and weights. States traditionally gather heavy-vehicle travel and weight information through traffic counting, classification, and truck weight monitoring programs. A number of states, including Texas, are participating in the Heavy Vehicle Electronic License Plate development program to demonstrate the applicability and use of automated vehicle identification (AVI), weight-in-motion (WIM) and automated vehicle classification (AVC). The project began in 1983 with Oregon and Arizona seeking means of improving truck weighing operations at weigh stations and port-of-entry. One of the technologies employed is fast speed weigh-in-motion scales that register vehicle weight, length, axle spacing, 18-kip ESALs, speed and time. AVI reader-activators read data from precoded passive transponders mounted on trucks, allowing automatic tracking. Finally, the Satellite Reference Design System is being developed for a satellite based traffic monitoring system. Iowa and Minnesota are testing piezo-electric sensors and inductive loops to detect off scale travel, tire width measurement, vehicle speed, classification by axle spacing, axle and gross weights and ESAL calculations. Eventually these technologies will provide better monitoring of truck movements, both for government enforcement of tax collection and industry fleet management, including reduction of theft (estimated at $7 billion annually nationwide). Truckers will benefit from time saved at weigh stations and fairer competition, due to increased costs of noncompliance with state regulations and taxation.[111]

Another issue that needs to be addressed is the impact on both the economics of the industry and the state from a weight-distance tax. Since a WDT would shift more of the tax burden onto trucks in general, and heavy trucks in particular, there is a potential for significant impacts on the industry. However, the primary competition for truckers, the railroads, is increasingly concentrated in shipments of dense cargo that are not time-dependent, with shipments of 14 commodities accounting for 70 percent of rail-traffic in manufactured goods. The only segment of the trucking industry that might be endangered would be the long-haul truckers. Operating costs for heavy trucks vary substantially for different carriers, ranging from below $1 per mile for efficient, long-haul operations to $2.50 and above for less-than-truckload carriers of general freight.[112] If a WDT replaced existing state taxes, it would only raise costs

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[111] Henion, L. and B. Koos, "The Heavy Vehicle Electronic License Plate System Development Program: A Progress Report," *Transportation Research Forum*, 27(1), 1986, p. 189-192 and "Technology and the Heavy Vehicle Electronic License Plate Program: Potential Uses For Government and Industry," *Transportation Research Record* N1107, TRB, National Research Council, Washington D.C., 1987, p. 46-50.

[112] FHWA Study, 1988.

by a few cents per mile (5-8 cents a mile is the highest tax in most states, and this usually replaces other truck fees), insufficient to cause a large shift to rail.

The effect on competition within the trucking industry could be significant, although the cost advantage for large firms would be less than $100 per vehicle and as low as $20 due to higher compliance costs for owner-operators. The problem is that owner operators appear to be concentrated in the long haul and truckload segments of the commercial trucking industry, which will experience the largest relative increase in costs from a WDT. They also drive more miles than the average heavy truck owner, thus increasing the total cost of the tax, though not the per mile impact.[113] However, if preservation of the small trucker, as with the preservation of the small farmer, is deemed a social good, then direct subsidization would be more efficient than distortionary taxes or prices.

The effect on the state economy would be practically nonexistent, since routes with rail competition would experience no increase in freight costs. While short-haul routes and noncompetitive routes might experience a slight increase in freight costs, it would be only a small percentage of freight costs, which in turn account for a very small percentage of costs for most goods. The increase in consumption due to lower gasoline taxes, if they are reduced, or the increase in productivity due to better roads, if the funds are invested in highway infrastructure, should be far greater than any economic losses associated with a WDT. In addition, the decline in expenditures for highway maintenance due to more efficient loading of trucks (for a social standpoint) because of a WDT should also be significantly greater than the impact of slightly higher freight charges.

Enforcement of Overweight Trucks

One of the additional benefits of a weight-distance tax will be to increase enforcement and rationalization of the regulation of overweight trucks. Since damage to roads increases exponentially with axle loading, additional weight on the heaviest trucks have a disproportional social cost. In 1983 the states were spending about $98 million to administer and conduct vehicle size and weight enforcement programs. Despite this expenditure a report by the DOT's Office of Inspector General found that overweight trucking was costing about $562 million ($740 million in 1990$) to the Interstate System alone. Overweight trucks accounted for 16.8% of all combination truck miles on urban Interstates and 9.5% of miles on rural Interstates. The estimated damage did not include damage by overweight vehicles with less than five axles or damage to bridges. Damage to non Interstates might be 300 to 400% greater, due to more travel

[113] "Statement of Lawrence Thompson, Chief Economist, GAO," in *Alternatives to the Heavy Vehicle Use Tax*, Hearing before the Committee on Ways and Means, House of Representatives, 98th Congress, 2nd Sess., Feb. 23, 1984, USGPO, Washington D.C.: 1984, p. 55-62

by combination vehicles and higher levels of deterioration costs per mile.[114]

The reason for extensive overloading of trucks is that truckers are rational economic actors. Truck costs rise relatively slowly with weight, so that cost per pound carried declines well above the legal limit. Therefore the truckers' willingness to overload will be a function of the decreased cost per unit (the benefit) and the fee to legally overload or the expected value of the cost of running the truck illegally (the cost). This expected cost depends on the size of the fine and the probability of detection. As long as benefits are greater than costs, the trucker will choose to overload; if the fee structure is such that costs do not increase as the overload increases, then the trucker will overload to the maximum the vehicle can handle. The two losers are society, which faces higher costs for road maintenance, and truckers who obey regulations and thereby face a competitive disadvantage.

In Texas, the maximum gross weight is 80,000 lbs., the maximum single-axle load is 20,000 lbs., and maximum tandem-axle load is 34,000 lbs. Analysis of the Texas Truck Weight Survey found that the number of overweight operations ranged from 21-25 percent of all operators in 1984. The CTR found that 24 percent of weighed vehicles exceeded legal limits by an average of 8,000 lb., with 90 percent of the violators being from the 3S-2 combinations. Overweight trucks accounted for a 7 to 12 percent increase in ESALs on Texas roads. Given a cost responsibility of 35% to 55% for combination trucks, overweight trucks should have been assigned $50-85 million of this cost responsibility for state roads in 1980. Instead it was found that overweight vehicles in Texas saved over $46 million by driving overweight in 1980.[115]

The problem in Texas is that its flat fee schedule encourages overloading of trucks, while the number of highway miles to be patrolled in Texas decreases the probability of detection. The use of a flat fee provides an economic incentive to overload to the truck's limit, as benefit increases without an associated increase in costs. The only deterrent in the current system is the threat of civil suits against trucking firms found to be flagrant and consistent violators of weight laws, and recovery of damages on a contempt of court basis. A more efficient system would be to set fines according to a set fee plus a charge per pound over the legal axle weight. By setting fines high enough and financing enforcement efforts at a sufficient level, overweight travel in Texas could be substantially reduced.[116]

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[114] USDOT, Office of Inspector General, "Report on Audit of Vehicle Size and Weight Enforcement Program in the Federal Highway Administration," in *Alternatives to the Heavy Vehicle Use Tax*, Hearing before the Committee on Ways and Means, House of Representatives, 98th Congress, 2nd Sess., Feb. 23, 1984, USGPO, Washington D.C.: 1984, p. 69-92.

[115] Euritt, Mark, "Economic Factors of Developing Fine Schedules for Overweight Vehicles in Texas," *Transportation Research Record* N1116, TRB, National Research Council, Washington D.C., 1987, p. 31-39.

[116] Euritt, 1987 and Casavant, K., J. Lenzi & B. Diseth, "An Economic Evaluation of the Fee and Fine Structure for Overloaded Trucks in Washington," *Transportation Research Board, 71st Annual Meeting*, Jan. 1992, Paper No. 920490.

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CHAPTER VII. MOTOR FUEL TAXES

History of Motor Fuel Taxation

Motor fuel taxes have traditionally been the primary source of highway revenues at both the federal and state levels for a number of reasons: their stability as a source of revenue, their strong correlation with highway use, and ease of administration and collection. The emphasis on motor fuel taxes began with the expansion of the state highway systems during the 1920s. The principle of nondivertibility of gasoline taxes originated in Great Britain, when a bargain was struck between the government and upper-class motorists in a debate over the 1909 Development and Road Improvement Funds Bill.

In the early 1900s, the nation's roads were simply not suitable for automotive and truck traffic. Only 8.7 percent of the roads in the United States were surfaced at all in 1909, a gain of 1.5 percent over 1904, when the first census of American roads was taken. Through the combined lobbying efforts of automobile interests and farmers newly made mobile by the Model T, the primitive road network of 1910 was transformed into an interconnected system of concrete highways by 1930. By the end of 1912 a number of major road-building projects were under way, and outstanding county/township road bonds totaled over $155 million, while authorized state good-roads expenditures totaled nearly $137 million. The Federal Aid Road Act of 1916 began the development of a national highway system, as the government committed itself to spending $75 million to build rural post roads, with the money to be spent by the Department of Agriculture over five years. The federal contribution was not to exceed 50 percent of the total construction cost, exclusive of bridges and other major structures, and was conditional on the organization of state highway departments with adequate personnel authority and sufficient equipment for initial work and subsequent maintenance.[117]

Following WWI, the federal government made available as military surplus to state highway departments for road building some 25,0000 heavy trucks and 1,500 caterpillar tractors. Demonstration of the value of long-distance trucking during the war and growing automobile registrations after the war led to passage of the Federal Highway Act of 1921. The Act amended the original law by requiring that the Secretary of Agriculture, in dispensing aid, give preference to states that had designated a system of highways to receive federal aid. A designated state system was to constitute the "primary" roads of the state and was not to exceed 7 percent of the states' total highway mileage. The 1921 legislation also created a bureau of Public Roads to plan a highway network to connect all cities of 50,000 or more inhabitants. In 1925 a uniform plan was adopted for designating and numbering the US highways that were part of the system. Congress appropriated as much money for a single year's construction as it had for all of the preceding five years, some $75 million for 1922 alone. In 1924 the amount of

[117] Flink, James, *The Automobile Age*, Cambridge, Mass: MIT Press, 1988 and Walton, Gary and Hugh Rockoff, *History of the American Economy*, 6th Ed., San Diego: Harcourt Brace Jovanovich, Publishers 1990.

federal aid per mile was stabilized at $15,000.[118]

In 1921 road construction and maintenance were financed mainly by property taxes and general funds, with only about 25 percent of the money for roads coming from automobile registration fees. Western states with sparse populations could not pay for roads out of property taxes or general funds, so to finance highway construction and maintenance, the gasoline tax was introduced in Oregon, New Mexico, and Colorado in 1919. By 1929 all states and the District of Columbia collected gasoline taxes, which amounted to some $431 million in revenue for highways that year. Rates of three or four cents a gallon were common, and gasoline taxes were the main source of revenue for highway expenditures, with twenty-one states no longer using any property taxes or general funds for main roads. The reasoning was that the gasoline tax as a user tax was a good measure of the use of the road and also of the damage that a vehicle did to the road. Politically, the perception that the tax was 'equitable' in itself and that those who paid it benefited directly made it a popular tax.[119]

Fueled with this new source of revenues, the value of highway construction projects exceeded $1 billion in 1925, thereafter, it fell below that figure only during a few years of the Great Depression and World War II. State appropriations increased from $70 million in 1918 to nearly $750 million by the end of the decade. In addition to this stimulus to government activity came the need for the bureaucracies to administer licensing, titles and registrations, and, of course, traffic courts. Even during the troubled thirties, however, state and federal funds were made available for roads because they employed many workers and could be planned quickly.[120]

As gasoline taxes become the main source of revenue for highway expenditures in the states, coalitions of state automobile clubs, taxpayers' associations, and road user groups, aided by their national affiliates and groups sponsored by the auto industry itself, worked to promote earmarking of gasoline tax revenues to highway use. Their favorite device was to insert an amendment into the state constitution, and Minnesota became the first state to adopt an earmarking amendment in 1920, with sixteen states following suit by 1962. In states where an amendment was not achievable, legislation was introduced to prevent diversion of highway user funds to purposes other than highway construction and maintenance. In 1974 forty-six of the fifty states had dedicated highway trust funds. At the federal level, Alfred Sloan of General Motors conceived the National Highway Users Conference (NHUC) in 1932 to prevent the diversion of gasoline taxes to other purposes during the Great Depression.[121]

A sharp drop in highway construction and maintenance during World War II required postwar construction for the greatly expanded number of motor vehicles. In 1944 Congress

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[118] Flink, 1988, Walton and Rockof 1990, and Jackson, Kenneth, *Crabgrass Frontier*, Oxford: Oxford University Press, 1985.

[119] Flink, 1988

[120] Jackson, 1985, and Walton and Rockoff, 1990.

[121] Flink, 1988, and Jackson, 1985.

planned a national system of interstate and defense highways. The promise of a national system of impressive roadways attracted a diverse group of lobbyists, including the Automobile Manufacturers Association, state-highway administrators, motor-bus operators, the American Trucking Association, and even the American Parking Association. In 1943 these groups came together as the American Road Builders Association, with General Motors as the largest contributor. By the mid-1950s, it had become one of the most broad-based of all pressure groups, consisting of the oil, rubber, asphalt, and construction industries; car dealers and renters; the trucking and bus concerns; the banks and advertising agencies that depended upon the companies involved; and the labor unions. On the local level, real-estate groups and home-builders associations joined the movement in the hope that highways would cause a spurt in housing turnover and a jump in prices. They envisaged no mere widening of existing roads, but the creation of an entirely new superhighway system and the initiation of the largest peacetime construction project in history.[122]

The Cold War provided an additional stimulus to the campaign for more elaborate expressways. To avoid national destruction in a nuclear attack, it was suggested that the United States should disperse existing large cities into smaller settlements. In 1956 the official name of the system became the National System of Interstate and Defense Highways. National defense was the major justification for increasing the federal share of funding from the 60-40 ratio in the 1944 Federal Aid Highway Act to 90-10 in the 1956 Interstate Highway Act, and for permitting federal funds from general tax revenues as well as special user taxes to be used for building the system. The lion's share of funding for the Interstate System came from special use taxes on cars, gasoline, tires, lubricants, and parts paid into the Highway Trust Fund, which could be used only for highway expenditures until August 1973 when President Nixon signed a $22.9 billion highway aid bill permitting diversion of the fund to urban mass transit.[123]

It is obvious from Table 7-1 that motor fuel taxes have dominated fund raising for state highway programs (the federal highway trust fund is basically a transfer to state highway programs), accounting for approximately half of revenues, with motor vehicle taxes an important secondary source of funds for the states. Local governments have been limited in their use of motor fuel taxation by state government and have depended on property and other local oriented taxation and fees, with the bulk of their funds coming from general revenues.

Traditionally, states had similar gas taxes, with most states between 5 and 7 cents per gallon during the 1960s and 7 to 8 cents in the early 1970s. The decline in gasoline consumption encouraged states to increase their tax rates during the 1980s, as revenues lagged behind the growth in construction costs. While the decline in prices since the early 1980s probably reduced the political resistance to these price hikes. There was also a shift to variable-rate taxes, adopted by 10 states, in which periodic rate adjustments are made according to

[122] Flink, 1988, and Jackson, 1985.

[123] Flink, 1988.

consumer price index or the FHWA's national highway cost index.[124] Texas lagged behind other states because it was able to use surplus state funds in the late 1970s to finance highways, but the combination of fiscal constraints and increased revenue requirements forced substantial increases in gasoline taxation during the last few years. The increase in distillate fuel taxation is both a response to the need for revenues and the growing awareness that trucks have not paid their full cost responsibility; increased distillate fuel taxation is a crude method (compared to a WDT) to improve vertical equity in highway taxation. Table 7-2 shows distillate fuel tax rates in selected states for the years 1970, 1975, 1980, 1985, and 1990.

Table 7-1. State Highway Funding 1920-1990 (millions of dollars)

Year	Motor Fuel Taxes	Motor Vehicle Taxes	Other	Bonds	Federal Funds Total	Federal Fuel Tax	Local Funding	Total
1990	18,298	9,659	7,888	3,122	14,131	10,522	683	53,781
1981	9,189	5,679	4,308	929	8,690	4,450	296	29,091
1970	4,215	2,102	834	1,302	4,737	3,776	1,511	17,066
1960	3,400	1,913	735	707	2,521	1,984	878	10,154
1950	1,652	935	191	410	426	534	565	4,179
1940	866	455	61	202	196	226	348	2,128
1930	495	356	130	222	94	—	622	1,919
1920	1	102	155	38	62	—	635	995

Source: Bureau of the Census, *Historical Statistics of the United States*, Washington DC: Department of Commerce 1975, *Highway Statistics*, various years. (Total does not include the federal fuel tax column.)

Impact of the Oil Supply Disruptions of the 1970s on Motor Fuels Tax Revenues

The revenues raised from a motor fuels tax are simple to calculate but harder to project. Revenue equals the rate of the tax (usually in terms of cents/gallon) times the quantity of fuel consumed. To project revenues one must predict the consumption of the fuel. In the past this was a fairly simple matter of projecting the expected volume of travel, and assuming the average consumption per mile would be constant. Since the price of gasoline and diesel fuel rarely varied by more than a few cents, consumer reactions to price changes could be ignored. However, the OPEC engineered price increases of the 1970s, and the subsequent price collapse of the 1980s have complicated the analyst's calculations. With a price rise of 330 percent

[124] Bowman, J. and J. Mikesell, "Recent Changes in State Gasoline Taxation: An Analysis of Structure and Rates," *National Tax Journal*, 36(2), 1985, p. 163-182.

between 1973 and 1981 in the nominal price of gasoline at the pump (the price consumers face) followed by a 45 percent decline by 1988, followed by an increase of 29 percent during the next

Table 7-2. Distillate Fuel Taxes for Selected States, 1970-90

Year	New York	Pennsylvania	Ohio	Illinois	California	Washington	Oregon	Texas
1970	9.0	8.0	7.0	7.5	7.0	9.0	7.0	6.5
1975	10.0	9.0	7.0	7.5	7.0	9.0	8.0	6.5
1980	10.0	11.0	7.0	7.5	7.0	12.0	8.0	6.5
1985	10.0	12.0	12.0	15.5	9.0	18.0	9.7	10.0
1990	27.0	23.8	20.0	26.0	9.0	22.0	18.0	15.0

Source: *Highway Statistics*, summary to 1985, annual 1990.
Note: Rates include tax where applicable. New York, Pennslyvania rate includes motor carrier gallonage tax.

two years and a second decline with the resolution of the crisis in the Persian Gulf, it is not surprising that consumers are very aware of the price of gasoline. With price changes of this magnitude, even a small short-term elasticity of demand for gasoline can result in significant shifts in consumption. Mitigating this effect is the smaller change in terms of real prices as can be seen from Table 7-3.

The impact of changing gasoline prices on motor fuel revenues can be seen at the federal level in Table 7-4. The federal tax stayed constant at 4 cents from 1959 until 1983, and the real value of revenues declined steadily from the peak year of 1971, when they reached 11.5 billion in 1989 dollars. The decline up to 1978 was due to inflation eroding the real value of the revenue collected, but by 1980 this effect was acerbated by a decline in nominal collections due to a drop in gasoline consumption (Diesel consumption declined in only one year, 1980, and has grown at 5% annually since that year). Despite the steady increase in vehicles per person, a decline in driving in the short-term, and more importantly, an increase in vehicle efficiency in the long-run, resulted in an overall decline in gasoline consumption from its 1978 peak. This explains the increase in federal gasoline taxes in 1983 to 9 cents a gallon (and diesel to 15 cents in 1984), despite which taxes as a percentage of gasoline prices are still below the level of 1973.

Currently the federal highway motor fuel tax is 14.1 cents on gasoline and special fuels used in highway vehicles, except gasohol, taxed at 8.7 cents per gallon, and diesel fuel taxed at 20.1 cents per gallon. The tax was increased in 1990 by 5 cents as part of the budget agreement, with 2.5 cents going to deficit reduction, 2 cents earmarked for the Highway Trust

Fund, and .5 cents for mass transit.[125]

Table 7-3. Motor Gasoline Prices 1973-1991 (cents per gallon at the pump)

	Leaded Regular		Unleaded Regular	
YEAR	Nominal	Real	Nominal	Real
1973	38.8	102.3	NA	NA
1974	53.2	129.0	NA	NA
1975	56.7	125.4	NA	NA
1976	59.0	122.8	61.4	127.8
1979	85.7	142.4	90.3	150.2
1980	119.1	180.9	124.5	189.0
1981	131.1	181.0	137.8	190.2
1982	122.2	158.8	129.6	168.5
1985	111.5	128.6	120.2	138.6
1986	85.7	96.3	92.7	104.2
1989	99.8	100.3	102.1	102.6
1990	114.9	110.9	116.4	112.3
1991	NA	NA	114.0	106.1

Source: Energy Information Administration, *Annual Energy Review 1991*, Washington DC: GPO 1992.
Note: Real prices in 1990$ using GDP inflator.

During the period 1973-1988, travel per capita in automobiles and light trucks rose slightly, but the number of vehicles increased from less than 90 million to around 120 million. The primary reason for the increase in drivers was the growth in the number of adults, and a secondary impact was due to the addition of women to the work force. The distance traveled per car during this period increased by 1.1% per annum, after the effect of higher prices are accounted for. The efficiency of autos increased by 33%, while light truck energy consumption

[125] TRIP, *1991 State Highway Funding Methods*, Washington DC: Road Information Program, May 1991.

declined by 19%. However the share of light trucks used as passenger vehicles tripled, rising to over 20% of private passenger stock over this period, reducing aggregate efficiency gains. In addition, load factors for passenger vehicles declined from approximately 2.2 occupants per vehicle to 1.7 passengers, as average household size decreased from 3.14 to 2.66 people. This increase in single-occupancy travel lowered the reduction of energy use per passenger-mile to

Table 7-4. Effect of Gasoline Price Changes on Federal Motor Fuel Tax Revenues

Year	Motor Fuel Tax Revenues (Billions of Dollars) Current $	1989$	Total Gas Consumption (Billion Gal.)	Per Capita Consumption (Gallons)	Gasoline Tax as Percentage of Price
1973	4.316	11.154	100.64	676.0	10.31
1974	4.435	10.476	96.50	635.6	7.52
1975	4.500	9.869	99.35	641.7	7.05
1976	4.375	9.081	104.98	665.2	6.78
1977	4.851	9.472	107.98	672.0	6.43
1978	4.868	8.886	112.24	686.3	6.13
1979	4.976	8.344	108.13	649.6	4.54
1980	4.565	6.932	101.18	597.5	3.28
1981	4.609	6.421	99.60	579.8	2.96
1982	4.852	6.395	98.48	566.2	3.12
1983	7.147	9.040	100.11	569.1	7.35
1984	10.578	12.861	101.42	569.5	7.51
1985	11.446	13.445	103.57	575.7	7.53
1986	11.574	13.230	106.76	585.6	9.67
1987	11.526	12.586	108.70	589.2	9.40
1988	11.923	12.482	109.82	589.4	9.35
1989	14.306	14.306	107.67	NA	8.49

Source: CBO, *Federal Taxation of Tobacco, Alcoholic Beverages, and Motor Fuels*, Washington DC: 1990.
Note: The Federal Gasoline tax was 4 cents/gallon until 1983 when it was raised to 9 cents. The Diesel tax was also 4 cents/gallon, rising to 9 cents in 1983, and 15 cents in 1984.

only 15% over the period. Also, an increasing share of miles driven occurred in areas with congested traffic, which lowers the efficiency of vehicles.[126]

Most of the increase in efficiency during this period came about through improvements in the economy and performance of new cars of a given interior volume; "downsizing" of the

[126] Schipper, L., Howarth, R. and H. Geller, "United States Energy Use From 1973 to 1987: The Impacts of Improved Efficiency," *Annual Review of Energy*, 15, 1990, p. 455-504, Marc Ross, "Energy and Transportation in the United States," *Annual Review of Energy*, 14, 1989, p. 131-171 and Gately, Dermot, "The US Demand for Highway Travel and Motor Fuel," *Energy Journal*, 11(3), 1990, p. 59-73.

fleet had only a minor impact on fuel economy, and occurred primarily during 1979-1980. Only one-tenth of the fuel-economy improvement in new cars was due to shifting to smaller cars. Power per unit of engine size has increased by 36%, while the ratio of weight to interior volume of cars was reduced by an average of 16%. These improvements were partially offset by a 12% increase in acceleration in the 1980s, resulting in a 5% decline in potential mileage. Care must be taken in interpreting mileage figures; EPA ratings overestimate potential mileage for new fleet vehicles by 15%. In addition, increased congestion, a higher rate of urban travel than used by EPA (63 % instead of 55%), and higher highway speeds than expected (59.7 mph instead of 55 mph) add a few percentage points to the overestimate. Heavy trucks have not shared in the fuel efficiency gains demonstrated by passenger vehicles, with only slight improvements in efficiency occurring along with substantial growth in both the number of trucks and miles per vehicle.[127] (Table 7-5)

While Americans tend to see themselves as overtaxed, and demonstrate resistance to any attempt to raise gasoline taxes, they pay a much smaller rate per gallon than any other OECD country. Even in high tax states, drivers pay at total of only 27-30¢/gallon compared to 62 cents in Canada, 80 cents in Australia, and rates between $1.50-2.70 in Europe and $3 per gallon in Japan. The difference in diesel taxation is less dramatic, though the 33¢/gallon in the United States is below that of most countries, which tend toward a range of taxation between 50¢ to a dollar a gallon.[128] Given this disparity, there is no reason to think that higher gasoline taxes would affect the international competitiveness of American industry.

Table 7-5. Highway Vehicle Activity and Energy Use in 1985

	# of Vehicles (Millions)	Miles per Vehicle (Thousands)	Total Miles (Trillions)	MPG
Household Automobile	104	9.7	1.01	17.2Fleet
Automobile	105	27.0	0.28	20[a]
Light Trucks (passenger)	28.7	9.6	0.28	13.3
Light Trucks (freight)	9.6	10.5	0.10	12.0
Heavy Trucks	4.1	23.0	0.35	5.4
Buses	0.6	10.0	0.006	NA

[a] Estimate between new-car fuel economy of 22 mpg and household fuel economy of 17.2 mpg.

Source: Ross, Marc, "Energy and Transportation in the United States," *Annual Review of Energy*, 14, 1989.

[127] Ross, 1989.

[128] Congressional Budget Office, *Federal Taxation of Tobacco, Alcoholic Beverages, and Motor Fuels*, Washington, DC: 1990.

Current Types of State Motor Fuel Taxes

There are two general types of motor fuel taxation rate structures: static unit taxes and variable fuel taxation, as summarized in Table 7-6.

Static unit taxes are based on a flat rate (cents per gallon) function of the quantity consumed. The major disadvantage of this type of taxation is that revenues collected do not keep pace with prices and are sensitive to fuel consumption levels. With the increase in highway costs due to inflation, the progress in vehicle fuel efficiency and the development of alternatives to gasoline, a number of states have adopted the variable form of motor fuel taxation.

Table 7-6. Status of State Motor Fuel Taxes by Type as of April 1991

Type of Motor-Fuel Fee	Number of States	States
Fees Levied in fixed - cents per -gallon	34	Alabama, Alaska, Arizona, Arkansas, Colorado, Connecticut, Delaware, District of Columbia, Idaho, Iowa, Kansas, Louisiana, Maine, Maryland, Minnesota, Mississippi, Missouri, Montana, Nevada, New Hampshire, New Jersey, New Mexico, North Dakota, Oklahoma, Oregon, So. Carolina, So. Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, Wyoming.
Fees Levied in variable form	10	Florida, Kentucky, Massachusetts, Michigan, Nebraska, No. Carolina, Ohio, Rhode Island, West Virginia, Wisconsin.
Fees Levied in both fixed and variable form	7	California, Georgia, Hawaii, Illinois, Indiana, New York, Pennsylvania.

There are two major categories of variable motor fuel taxes: (1) ad-valorem taxes based on the market value of fuel (% of fuel price), which is a "sales tax"; and (2) indexed fuel taxes where a supplement is added to the primary ad-valorem tax. The different types of variable motor fuel taxes used by different states in April, 1991 are summarized in Table 7-7. The supplement can be in three forms:

- a sales tax levied at the retail level,
- a percentage based on fuel price either at the retail or wholesale level (levied in addition to the fixed - cents - per gallon fee),
- an indexed supplement related to different bases such as the Comsumer Price Index (CPI), the Federal Highway Maintenance and Operations Index, and the Federal Operations and Maintenance Cost Index.

Floor and ceilings are set to avoid sharp losses or profits occurring with fast variations in fuel prices.

Table 7-7. Status of Variable Motor Fuel Taxes in April 1991

Fee Type	Number of States	States	Rate
Ad-Valorem	3	Kentucky, Massachusetts Rhode Island	% average dealer wholesale price % of the state's average wholesale price of motor fuel % of the weighted average wholesale price of gas + excise tax % of wholesale price
Sales Tax Supplement	11	California Georgia Hawaii Illinois Indiana New York Pennsylvania Florida North Carolina West Virginia Michigan	15 c/g + 6% retail 7.5 c/g + 4% retail 11 c/g + 4% retail 19 c/g + 5% retail 15 c/g + 5% retail 8 c/g + 4% retail 12 c/g + 6% wholesale (franchise tax) 8 c/g + 6% retail 17.25 c/g + 7% wholesale 15.5 c/g + 5% wholesale 15 c/g + 4% retail
Percent Levy Supplement	1	Nebraska	% excise tax on the average price of motor fuel paid by the state for its vehicles
Indexed Supplement	2	Ohio Wisconsin	Indexed to the FHMO index Indexed to the FHMO index

Gasoline Demand, Price Changes, and Taxation

In the short term reductions in fuel use due to price increases come from reductions in discretionary driving, which does not appear to include work-related transportation as was evident during the oil supply disruptions in the 1970s. With the stock of motor vehicles held constant, fuel consumption can be reduced by curtailment of travel, switching to mass transit, and improved automobile maintenance. Decisions such as greater vehicle efficiency or choice of residential location to reduce distance traveled to work or type of transportation mode employed for commuting to work do not seem to be impacted by small changes in gasoline prices. These larger decisions, usually involving an investment in new capital or a serious change in lifestyles, require large price changes which are expected to be persistent.

One reason for the relatively small short-run and even long-run elasticity of demand for gasoline is because fuel costs are an increasingly small component of the total cost of vehicle ownership (fuel costs are less than 10 percent of long run travel costs for new cars). Ironically, one of the reasons is the increase in automotive efficiency due to the oil price shocks of the 1970s, that resulted in lower gasoline consumption of most automobiles and thus the lifetime fuel costs of these vehicles. Drivers are not making a decision concerning how much fuel they want to consume but how much they want to drive, and gasoline consumption enters this decision through its impact on costs, both when purchasing a vehicle and thenin deciding to drive. Higher gasoline prices raise the cost per mile, while higher fuel efficiency lowers the marginal cost of driving. Price elasticity of demand estimates of mileage for light-duty vehicles are in the range between -0.05 to -0.15 in the short- run and around -0.25 in the long-run. This suggests that while fuel costs comprise the majority of short-run variable monetary costs of travel, these are dominated by the value of time to the traveler. There does not seem to be a substantial long-run effect, probably because rising fuel costs result in adjustments that counterbalance the increase in costs, such as cars with higher fuel efficiency. Increases in fuel efficiency should cause some increase in driving (the "rebound effect"), but gasoline consumption per vehicle will decline.[129]

Dahl and Sterner provide a review of various studies of gasoline elasticities, finding a wide range of estimates (An elasticity is the percent change in volume due to a percent change in price or income. Short-run usually applies to the change occurring within a year of the price change; long-run applies to the change occurring 5 to 10 years after the change in price or income). After analyzing the various models, they were able to group studies into a range of reasonable estimates and determined an average value of -0.22 in the short-run and -0.92 in the long-run for the price elasticity of demand, and .44 and 1.10 for the short and long-run income elasticity of demand. Table 7-8 provides their results as well as summaries of previous

[129] Greene, David, "Vehicle Use and Fuel Economy: How Big is the 'Rebound' Effect?" *Energy Journal*, 13(1), 1992, p. 117-143.

reviews.[130]

A simple application of these elasticity estimates to projecting revenues from a gasoline tax would be to calculate changes in current revenues. While the formula looks complex, it is basically a matter of adjusting gasoline consumption for the effect of changes in income and gasoline prices, and then determining revenues.

Revenue = [Current gasoline consumption x (1 + ((% change in state income/100) x 0.44)) x (1 + ((% change in oil price/100) x -0.22))] x (the tax rate).

Table 7-8. Reviews of Estimates of Gasoline Demand Elasticities

Study	Price Short-run	Price Long-run	Income Short-run	Income Long-run	Date (# of studies)
Dahl and Sterner	-0.22	-0.92	0.44	1.10	1988 (97)
Dahl	-0.29	-1.02	0.47	1.38	1984 (68)
Bohi & Zimmerman	-0.26	-0.70	0.42	0.80	1982 (9)
Bohi	-0.22	-0.58	0.39	1.09	1979 (11)

Source: Dahl, Carol and T. Sterner, "Analyzing Gasoline Demand Elasticities: A Survey," *Energy Economics*, 13(3), July 1991.

This simple model may not be that trustworthy, however, since elasticity estimates implicitly assume that the underlying structure of the model is not shifting over time. However there have been some drastic changes over time, including shifts in the number of drivers, characteristics of drivers, and automotive engine technology. Growth in the number of drivers has been declining from 2.9% annually from 1966-77, 1.6% from 1977-88, and should slow to 1.1% during the 1990s. The number of employed men, who drive more than other drivers, has stabilized, and women's participation in the work force has leveled off after rising for three decades. As the number of households with more than one vehicle increases, the median age of cars has increased, rising two years since the early 1970s, and many of these cars are limited use, special vehicles. The shift to light trucks (including minivans) may also stabilize as baby boomers finish household formation.[131]

[130] Dahl, Carol and T. Sterner, "Analyzing Gasoline Demand Elasticities: A Survey," *Energy Economics*, 13(3), July 1991, p. 203-210.

[131] Ross, 1989, and Gately, 1990.

This suggests that an alternative method of projecting gasoline tax revenues would be to determine the miles driven, taking in account the changing composition of both the driving population and the automotive fleet. Given total mileage, and the average mileage of the fleet of vehicles, gasoline consumption, and therefore tax revenues can be estimated. Gasoline prices and income would then enter the model through the impact on driving behavior and new car purchases. One advantage of this approach is that it allows simulation of the impact of various changes in fuel standards or automotive emissions regulations. However, it requires more data than the simple elasticity method, and a larger group of assumptions concerning future behavior.

Tax revenues from distillate taxes (or a weight-distance tax) are simpler to estimate since heavy truck travel has been more consistent in its behavior. Gately estimated that truck miles traveled had an income elasticity in the range of 1.16-1.18 and a fuel price elasticity of -0.029-0.035.[132] This suggests that fuel prices will have little impact on truck mileage, and the major determinant of miles traveled and fuel used will be the demand for freight delivery.

Distributional Impacts of Gasoline Taxes

As can be seen from Table 7-9, expenditures on motor fuels tend to vary far less than income, especially when households without vehicles are excluded from average expenditures. With the almost universal saturation of light vehicles, only among the poorest fifth of households is there any lack of access to a motor vehicle. Not surprisingly, the southern and rural households drive the most miles, while only in the Northeast do people live without cars. This implies that in a state like Texas, even poor households find themselves obliged to own and operate a motor vehicle, which would tend to increase the potential regressive impact of a gasoline tax.

A tax increase on motor fuels is likely to be completely passed through in the short-run due to the small elasticity of demand. Long run impacts depend on the extent to which demand becomes more elastic over time. As we've seen, most estimates of price demand for gasoline suggest that demand is inelastic even in the long-run.

The Congressional Budget Office simulated the impact of a 12 cent/gallon motor fuel tax increase (assuming a 25% business share for gasoline and 90% for diesel fuel) using data from the consumer expenditure survey, the current population survey and the statistics of income. A price elasticity of -0.2 for motor fuels was used in the modeling exercise. The results were calculated for the tax alone, and with indexing of social security and other transfer payments due to the inflationary impact of the tax. The result was that the tax is definitely regressive, both before and after indexing (Table 7-10).

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[132] Gately, 1990.

Table 7-9. Expenditure on Motor Fuels by Family Income in 1990

Households	Average Post-Tax Income	Average Expenditures on Motor Fuels	Percentage of of Post-Tax Income	Percentage of Families with Expenditures	Average Expenditures on Motor Fuels
Bottom Quintile	8,228	570	6.9	80.4	709
Second Quintile	18,101	765	4.2	91.3	838
Middle Quintile	27,314	952	3.5	95.9	993
Fourth Quintile	37,581	1,099	2.9	98.5	1,116
Top Quintile	77,622	1,185	1.5	99.6	1,189
Census Region					
Northeast	38,467	803	2.1	88.4	909
Midwest	33,406	908	2.7	95.1	955
South	34,179	951	2.8	93.0	1,023
West	38,256	949	2.5	96.1	987
Rural	26,768	1,032	3.9	95.8	1,078

Source: CBO, *Federal Taxation of Tobacco, Alcoholic Beverages, and Motor Fuels*, Washington DC: 1990.

Table 7-10. Impact of a 12 Cent Motor Fuel Tax Increase

	Additional Tax ($)	As % of Income	Additional Tax After Indexing	As % of Income After Indexing
Bottom Quintile	99	1.2	81	1.0
Second Quintile	127	0.7	103	0.6
Middle Quintile	158	0.6	132	0.5
Fourth Quintile	187	0.5	152	0.4
Top Quintile	223	0.3	175	0.2

Source: CBO, *Federal Taxation of Tobacco, Alcoholic Beverages, and Motor Fuels*, Washington DC: 1990.

Data on expenditures and income from household expenditure surveys gives a very different picture than does the income data alone that was analyzed by the CBO. Table 7-11 shows several types of information from the U.S. Department of Commerce's consumer expenditure survey, which has been collected for over 100 years. The data is shown in Table 7-11 for all consumer units and for each quintile, arrayed across the columns of the table from left to right in increasing order of income quintile. Shown in the table are several items for each year from 1985 through 1989. Within each year, the first two rows show annual income before and after taxes. The next three rows show annual total transportation expenditures and two components of transportation expenditures: expenditures on gasoline and oil and expenditures on maintenance and repairs. The last three rows for each year show the same three transportation expenditure items as a percent of total annual expenditure.

One of the first items that may be noted in this table is that expenditures exceed income after taxes for the lowest three quintiles and is about even for the fourth quintile. Expenditures actually exceed income after taxes for the fourth quintile in the last year for which data are available, 1989. Only for the highest income quintile does income after taxes exceed expenditures. This might at first lead to the false supposition that many types of income are excluded. In fact, most types of income are included in income as defined in this table. This income includes all types of income for individuals 14 years of age or older in a household, including: salaries and wages; self-employment income; social security, private and government retirement; interest, dividends, rental income, and other property income; unemployment and workers' compensation and veterans' benefits; public assistance, supplemental security income, and food stamps; regular contributions for support; other income including income from care of foster children, cash scholarships, fellowships, or stipends not from working, and meals and rent as pay; and federal, state, and local taxes, including taxes withheld from income.

However, income is not defined as including most money derived during the year from changes in net assets, such as sale of securities, lump sum payments from trusts, estates, insurance, gifts of goods and services, reduction in checking or saving accounts, etc. Also excluded, of course, would be any unreported income.

Overall, this income and expenditure information indicates that household units have available to them total funds for expenditures that substantially exceed income net of taxes. Presumably this is mostly from households "dis-saving," either through using up assets or through borrowing, and perhaps partially from unreported income from various sources.

The most interesting item with respect to the present inquiry on the equity of motor fuel taxes is the relative constancy shown by expenditures for transportation, and especially for the gasoline and oil subcategory, as a percent of all expenditures, for each quintile. In 1984, the percent of total expenditures represented by gasoline and oil was about five percent (5.1, 5.6, 5.4, and 5.0) at all income quintiles except the highest income, for which it was 3.9 percent. By 1989, this percent of expenditures represented by gasoline and oil had declined to about four percent (3.8, 4.0, 4.1, 3.6) at all except the highest quintile; at the highest quintile in 1989, expenditures for gasoline and oil represented 2.9 percent of total expenditures.

For ease in comparing the percentage of income and expenditures spent on gasoline and oil by year, Table 7-12 presents percentages for the last five years for which data are available. The percentages for income are similar to those from the Congressional Budget Office that were presented in the previous discussion. Since the data showing gasoline and oil expenditures as a percent of income differ substantially from those showing such expenditures as a percent of total expenditures, the question of the equity of motor fuel taxes then rests mainly on which unit, income or total expenditures, shows "how well off" households are. In this study, the position is supported that money spent for all types of goods and services during a year is a better measure of well-being than income.

Taking the position that total expenditures are the better measure of well-being for a household leads to different conclusions than those reached by the CBO. The percentages in the table indicate that all levels of income are affected fairly equally in terms of the impact on funds available for expenditure on all items, as measured by expenditures as a percent of all expenditures. Therefore, from the expenditure data, it can be concluded that a motor fuel tax meets the equity criteria for good taxes much better than the income data used in the Congressional Budget Office study indicate. Moreover, the percent of income spent on gasoline and oil decreased substantially over the last five years for which data are available (1984-1989), from about five percent to about 4 percent.

It is concluded overall that motor fuel taxes affect households with different incomes roughly in proportion to the total money spent on all expenditures, and, therefore, such taxes are not regressive with respect to total funds available for expenditures at each level of income.

A better understanding of the preceding information can be reached by comparing average annual miles traveled per household with the expenditures on gasoline and oil at different levels of income, shown in Table 7-13.

Additional information is provided in Table 7-14 showing the cost of owning and operating an automobile for various years from 1950 to 1991. This information can be further analyzed to show the changing costs of owning an automobile relative to the tax per gallon of motor fuel over time. This cost information is developed assuming a vehicle travels 10,000 miles per year. Although the average miles per household increases up to 31,646 for the highest income quintile, this assumption probably is still fairly valid since most of the increase in miles traveled is from households owning additional automobiles more than it is from increases in miles per automobile.

Table 7-11. Consumer Income, Total Expenditures, and Transportation Expenditures, 1984-1989.

1984	All Consumer Units	Lowest 20 percent	Second 20 percent	Third 20 percent	Fourth 20 percent	Highest 20 percent
Income before tax	$23,464	$3,169	$10,250	$18,340	$29,008	$56,426
Income after tax	21,237	3,137	9,751	17,068	26,247	49,871
Average annual expenditures	21,975	10,894	14,337	19,469	26,138	41,825
Transportation Expenditures	4,304	1,972	2,814	3,891	5,218	8,053
Gasoline and motor oil	1,058	559	797	1,056	1,301	1,649
Maintenance and repairs	481	270	322	494	598	829
Shares of total annual expenditures (%)						
Transportation	19.6	18.1	19.6	20.0	20.0	19.3
Gasoline and motor oil	4.8	5.1	5.6	5.4	5.0	3.9
Maintenance and repairs	2.2	2.5	2.2	2.5	2.3	2.0
1985						
Income before tax	$25,127	$3,594	$10,811	$19,397	$30,967	$60,741
Income after tax	22,887	3,463	10,338	18,131	28,178	54,215
Average annual expenditures	23,490	11,417	15,092	20,374	27,760	45,166
Transportation Expenditures	4,587	1,860	2,866	4,286	5,699	8,520
Gasoline and motor oil	1,035	538	781	1,011	1,319	1,578
Maintenance and repairs	473	224	340	443	580	845
Shares of total annual expenditures (%)						
Transportation	19.5	16.3	19.0	21.0	20.5	18.9
Gasoline and motor oil	4.4	4.7	5.2	5.0	4.8	3.5
Maintenance and repairs	2.0	2.0	2.3	2.2	2.1	1.9
1986						
Income before tax	$25,460	$3,811	$10,766	$19,534	$31,627	$61,477
Income after tax	23,172	3,667	10,371	18,140	28,749	54,857
Average annual expenditures	23,866	11,477	14,639	21,088	28,698	46,242
Transportation Expenditures	4,842	2,023	2,722	4,247	6,055	9,368
Gasoline and motor oil	915	488	657	905	1,167	1,395
Maintenance and repairs	492	222	334	495	600	880
Shares of total annual expenditures (%)						
Transportation	20.3	17.6	18.6	20.1	21.1	20.3
Gasoline and motor oil	3.8	4.3	4.5	4.3	4.1	3.0
Maintenance and repairs	2.1	1.9	2.3	2.3	2.1	1.9
1987						
Income before tax	$27,326	$4,611	$11,954	$20,943	$33,276	$65,750
Income after tax	24,871	4,494	11,424	19,500	30,373	58,477
Average annual expenditures	24,414	10,355	15,686	21,708	29,603	46,470
Transportation Expenditures	4,600	1,552	2,917	4,148	5,923	8,389
Gasoline and motor oil	888	372	641	891	1,120	1,382
Maintenance and repairs	514	193	380	471	674	929
Shares of total annual expenditures (%)						
Transportation	18.8	15.0	18.6	19.1	20.0	18.1
Gasoline and motor oil	3.6	3.6	4.1	4.1	3.8	3.0
Maintenance and repairs	2.1	1.9	2.4	2.2	2.3	2.0
1988						
Income before tax	$28,540	$4,942	$12,872	$22,570	$34,974	$67,199
Income after tax	26,149	4,854	12,309	21,174	32,125	60,157
Average annual expenditures	25,892	10,893	16,880	23,290	32,084	48,718
Transportation Expenditures	5,093	1,660	3,142	4,881	6,844	9,158
Gasoline and motor oil	932	459	659	926	1,204	1,420
Maintenance and repairs	553	215	387	540	702	998
Shares of total annual expenditures (%)						
Transportation	19.7	15.2	18.6	21.0	21.3	18.8
Gasoline and motor oil	3.6	4.2	3.9	4.0	3.8	2.9
Maintenance and repairs	2.1	2.0	2.3	2.3	2.2	2.0
1989						
Income before tax	$31,308	$5,720	$13,894	$23,856	$37,524	$75,406
Income after tax	28,496	5,669	13,348	22,233	34,183	66,923
Average annual expenditures	27,810	12,119	17,616	24,476	34,231	53,093
Transportation Expenditures	5,187	1,989	3,199	4,563	7,219	9,401
Gasoline and motor oil	985	465	700	998	1,217	1,555
Maintenance and repairs	561	239	375	517	758	1,011
Shares of total annual expenditures (%)						
Transportation	18.7	16.4	18.2	18.6	21.1	17.7
Gasoline and motor oil	3.5	3.8	4	4.1	3.6	2.9
Maintenance and repairs	2	2	2.1	2.1	2.2	1.9

Sources: U.S. Department of Commerce, BLS, Consumer Expenditure Survey, U.S. GPO, various issues.

Table 7-12. Consumer Expenditures Surveys, 1984-1989

		Expenditure on Gasoline and Motor Oil as Percent of:		
		Income Before Tax	Income After Tax	Average Annual Expenditure
1984	All Consumer Units	4.5	5.0	4.8
	Lowest 20 percent	17.6	17.8	5.1
	Second 20 percent	7.8	8.2	5.6
	Third 20 percent	5.8	6.2	5.4
	Fourth 20 percent	4.5	5.0	5.0
	Highest 20 percent	2.9	3.3	3.9
1985	All Consumer Units	4.1	4.5	4.4
	Lowest 20 percent	15.0	15.5	4.7
	Second 20 percent	7.2	7.6	5.2
	Third 20 percent	5.2	5.6	5.0
	Fourth 20 percent	4.3	4.7	4.8
	Highest 20 percent	2.6	2.9	3.5
1986	All Consumer Units	3.6	3.9	3.8
	Lowest 20 percent	12.8	13.3	4.3
	Second 20 percent	6.1	6.3	4.5
	Third 20 percent	4.6	5.0	4.3
	Fourth 20 percent	3.7	4.1	4.1
	Highest 20 percent	2.3	2.5	3.0
1987	All Consumer Units	3.2	3.6	3.6
	Lowest 20 percent	8.1	8.3	3.6
	Second 20 percent	5.4	5.6	4.1
	Third 20 percent	4.3	4.6	4.1
	Fourth 20 percent	3.4	3.7	3.8
	Highest 20 percent	2.1	2.4	3.0
1988	All Consumer Units	3.3	3.6	3.6
	Lowest 20 percent	9.3	9.5	4.2
	Second 20 percent	5.1	5.4	3.9
	Third 20 percent	4.1	4.4	4.0
	Fourth 20 percent	3.4	3.7	3.8
	Highest 20 percent	2.1	2.4	2.9
1989	All Consumer Units	3.1	3.5	3.5
	Lowest 20 percent	8.1	8.2	3.8
	Second 20 percent	5.0	5.2	4.0
	Third 20 percent	4.2	4.5	4.1
	Fourth 20 percent	3.2	3.6	3.6
	Highest 20 percent	2.1	2.3	2.9

Sources: U.S. Department of Commerce, Bureau of Labor Statistics, *Consumer Expenditure Survey*, U.S. GPO, various issues and authors' calculation.

Table 7-13. Expenditures and Miles Traveled Per Household, by Income After Tax, 1989

Income After Tax	Average Annual Expenditures	Expenditures for Gasoline and Oil	Annual Miles Traveled Per Household
$5,669	$12,119	$465	10,653
13,348	17,616	700	12,697
22,233	24,476	998	16,982
34,183	34,231	1,217	27,295
66,9123	53,093	1,555	31,646

Sources: U.S. Department of Commerce, Consumer Expenditure Survey; Goff from Energy Information Agency, p. 85.

Table 7-14. Cost of Owning and Operating an Automobile: 1950 to 1991, selected years

	Unit	1950	1955	1960	1965	1971	1975*	1980*	1985*	1989*	1990*	1991*
COST PER MILE	cents	8.61	9.53	11.99	11.77	15.5	18.31	27.95	27.2	38.2	40.96	43.64
COST PER 10,000 MILES	dollars	861	953	1,199	1,177	1,550	1,831	2,795	2,720	3,820	4,096	4,364
VARIABLE COST	cents/mile	3.28	3.54	3.9	3.7	4.25	6.45	7.62	8.04	7.9	8.4	9.8
Gas and Oil	cents/mile	2.14	2.29	2.62	2.58	2.96	4.82	5.86	6.16	5.2	5.4	6.7
Maintenance	cents/mile	0.68	0.74	0.79	0.68	0.73	0.97	1.12	1.23	1.9	2.1	2.2
Tires	cents/mile	0.46	0.51	0.49	0.44	0.56	0.66	0.64	0.65	0.8	0.9	0.9
FIXED COST	dollars	533	599	809	807	1,125	1,186	1,610	1,871	2,908	3,197	3,438
Insurance**	dollars	75.5	104.46	140.14	157	362	383	490	503	663	675	726
License & Registration	dollars	15.47	16.83	22.4	24	25	30	82	115	151	165	169
Depreciation	dollars	442	477	646	626	738	773	1,038	1,253	2,094	2,357	2,543
Finance Charge	dollars	-	-	-	-	-	-	423	570	626	680	779

* Vehicle specified for 1974 and later years is an intermediate. Prior to 1974 full sized vehicles were specified.
** Insurance includes fire and theft, collision (not available prior to 1967), and property damage and liability.
Source: Motor Vehicle Manufacturers Association of the U.S., Inc., *Motor Vehicle Facts and Figures*, 1991, Detroit, Michigan.

Fuel Efficiency

Corporate Average Fuel Economy standards, established through Title V of the Motor Vehicle Information and Cost Savings Act, had a significant impact on gasoline mileage during the 1975-85 period, even when the consumer reaction to rising gasoline prices is accounted for. It is estimated that after 1982, average mileage of new cars purchased would have begun to decline had it not been for standards (19 mpg in 1985 without standards vs. 26 mpg).[133] Given consumer demand for features that conflict with fuel economy, including vehicle size, performance, and luxury features, increased efficiency is unlikely without continued regulation.

There is substantial potential for continued improvement in fuel efficiency of automobiles, though it will require government mandates or far higher gasoline prices than presently experienced. It has been estimated that each additional mile per gallon will require a $40-50 increase in the retail price of vehicles in the 30 to 50 mpg range. It is unlikely that consumers will demand these improvements, since there would be a four to five year payback for the investment in increased efficiency. Without strong consumer demand for these improvements manufacturers will be unwilling to incur the technological risks and opportunity costs involved in the introduction of new fuel efficient technology.[134] OTA estimates that continuation of current trends would result in a new fleet mileage of 29.2 in 1995, and 30.0 mpg given regulatory pressure for increased efficiency without size shifts. By the year 2000, the new fleet could reach 32 mpg without drastic changes in composition or technology, in line with the 31-32 mpg projected by Energy Information Administration (EIA) and Data Resources, Inc.[135]

OTA projects that new car fuel economy levels of 32-33 mpg (EPA ratings) are unlikely to be achieved by 1995 without restraining performance levels to 1987-88 levels as far as acceleration and vehicle weight and market penetration of four wheel drive. Lighter cars needed to meet CAFE have been associated with a 14-27% increase in occupant fatality risk, and the elasticity of fatalities with regard to vehicle weight is in a range varying from -1.2 to -2.3.[136] However, reducing weight lowers the risk to the other car in an accident, and the variance in accident rates within weight classes suggests that the relationship between weight and safety involves a number of dimensions including interior space and structural design, as well as self-selection by risky drivers of smaller, faster vehicles. In addition, the proliferation of new safety devices (airbags, ABS) decreases the potential loss of life.[137]

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[133] Yee, Jet, "Effect of Consumption Standards on U.S. Gasoline Consumption," *Journal of Policy Modeling*, 13(2), Summer 1991, p. 205-227.

[134] Ross, 1989

[135] Office of Technology Assessment, *Improving Automobile Fuel Economy: New Standards, New Approaches*, Washington DC: GPO 1991.

[136] Crandall, R. and J. Graham, "The Effect of Fuel Economy Standards on Automobile Safety," *Journal of Law and Economics*, 32, April 1989, p. 97-118.

[137] OTA, 1991.

Achievement of significant improvements in mileage will be far more difficult for the light truck category of passenger vehicles. Large Pickup trucks present the most difficulty since the weight constraint is the payload, not vehicle weight, while the open cargo bed limits the potential for aerodynamic improvements. The use of all available technologies, including diesel engines for larger trucks, could allow light-truck new fleet fuel economy to improve from about 20 mpg to about 26 mpg by 2001. EIA and Data Resource estimates for the year 2000 project 23-24 mpg for light trucks. Given a one-third share of the total light vehicle fleet average, new vehicle mileage in the year 2000 could be around 29 mpg.

Even if there is substantial improvement in new vehicle mileage, it will take some time for the average mileage of the entire fleet to increase. As can be seen from Table 7-15, most vehicles are driven for substantial mileage as long as eight years, and they will still be on the road for an additional 30,000 miles after this point. This not only means that more efficient cars will require years before they have a major impact on total fleet efficiency, but that mileage will continue to increase as older cars are gradually removed from the present vehicle population. This will have two impacts, an increase in overall mileage as older vehicles are retired, and a decrease in the regressive nature of gasoline taxes as more efficient vehicles trickle down to the poorer drivers.

Table 7-15. Average Miles Traveled per Vehicle in 1988 by Vehicle Year (in thousands)

**-74	75-76	77-78	79-80	1981	1982	1983	1984	1985	1986	1987	1988-89
6.3	7.7	8.7	9.5	10.0	10.8	10.6	11.5	12.1	12.6	13.4	12.9

Source: Motor Vehicle Manufacturers Association, *MVMA Motor Vehicle Facts & Figures '90*.

Pollution Externalities

Estimates of the damages from motor vehicle emissions are on the order of 3.5 to 11 cents per gallon of fuel consumed, which is in line with values provided by the State Highway Cost Allocation (SHCA) Guide (1.5 cents/mile for automobiles, 3-4 cents/mile for diesel trucks in urban areas; 0.0 and 0.2 cents/mile respectively for rural areas). Lee estimates a cost of about 1.1 cent/vehicle-mile. Furthermore, these numbers include only the traditional cost of illness, medical treatment costs plus lost earnings. Approaches that use a value of life from revealed preference methods would yield estimates as much as four times higher. Unfortunately, there is a great deal of uncertainty with regard to benefits from pollution reduction--estimates from a study of ozone reduction ranged from $51 million to $4.7 billion.[138] Noise pollution value given by Lee was 0.2 cents/mile; SHCA gives 0.1 cent/mile for autos and 4 cents/mile for trucks in urban areas. These estimates are average values; the benefits from reducing pollution in highly polluted areas could be much higher.[139]

One irony of mandating increased fuel-efficiency is that the reduction in the engine's emission rate (depending on the technology employed to reduce fuel consumption) encourages auto manufacturers to reduce their investment in the emission control system in order to just meet the standards. This is due to the EPA policy of exhaust emission control through setting standards specified in terms of grams of pollutants per mile traveled. In this case, a gasoline tax that reduces miles driven will reduce emissions in the short run, but in the long-run, as drivers shift to more efficient cars, they will drive more miles, permitting more pollution under the current standards. Since miles driven is even less price elastic than gasoline, a gasoline tax would be far less effective in reducing pollution than an emissions tax in the long run.[140]

A more complex issue will be the problem of greenhouse gases. These are directly related to fuel consumption since it is the burning of carbon which produces CO_2, though carbon monoxide, hydrocarbons and nitrous oxides can also contribute to the problem. Since the *existence* of the greenhouse effect, much less the actual cost, is still an area of controversy, it would be difficult to assign a cost to emissions at this time. Alternative fuels for transportation that lower production of greenhouse gases over the full fuel cycle such as electric vehicles, hydrogen from nonfossil electric sources, and biomass are noneconomic at the present time. Compressed natural gas would lower emissions about 20%, while most other alternatives including methanol result in little improvement.[141] Therefore, reduction of transportation produced greenhouse gases will require lower fuel consumption. This in effect, would imply a large cost to be assigned to the greenhouse effect to justify the cost of a substantial reduction in fossil fuel consumption for such a high-valued use.

Clean Air Act of 1990 and Alternative Fuels

The importance of the Clean Air Act of 1990 to highway tax revenues will be its impact on use of alternatives fuels and fuel consumption of conventional vehicles. By 1996 standards will be issued for vehicle fleets of ten or more that are centrally fueled in CO and ozone non-

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[138] CBO 1990, FHWA, *State Highway Cost-Allocation Guide*, October 1984, Washington DC: GPO 1984 and Lee, Douglass, "Net Benefits From Efficient Highway User Charges," *Transportation Research Record* N858, TRB, National Research Council, Washington D.C., 1982, p. 14-20.

[139] FHWA, 1984, and Lee, 1982.

[140] Khazzoom, J. Daniel, "The Impact of a Gasoline Tax on Auto Exhaust Emissions," *Journal of Policy Analysis and Management*, 10(3), Summer 1991, p. 435-453.

[141] DeLuchi, M., R. Johnston, and D. Sperling, "Transportation Fuels and the Greenhouse Effect," *Transportation Research Record* N1175, TRB, National Research Council, Washington D.C., 1988, p. 33-44.

attainment areas. Thirty percent of fleet cars and light-duty trucks will need to meet the requirements by 1998, 50 percent by 1999, and 70 percent by 2001. Fifty percent of heavy trucks will need to comply with standards by 1998. By 1998 fleets will be required to reduce emissions by 80 percent for cars and 50 percent for trucks. Standards will also be issued for urban buses for 1994, and existing buses with rebuilt engines after 1995.[142] The requirement for cleaner gasoline will also be an incentive for increased sales of gasohol.

While California will be the testing ground for clean fuel and alternative fuel technologies, the fleet requirements of the Clean Air Act will prompt a switch away from petroleum based fuels to either methanol or compressed natural gas (CNG) over the next decade or two. Methanol is unlikely to penetrate the Texas market except as a possible blending agent with gasoline in areas where clean gasoline is required for vehicles. The current world methanol market is 6 billion gallons/year, compared to a gasoline/diesel market equal to 260 billion gallons/year of methanol. A commercial sized plant would take five years to build (1.2 billion gallon/year capacity, equivalent to 700 million gallons of gasoline), cost $880 million to build and $60-70 million per year to operate, not including the cost of natural gas.[143] Since the world's supply of inexpensive natural gas is located in the Middle East and the former Soviet Union, a massive shift to methanol could result in a new dependency on energy imports. Currently, methanol fuel is taxed at 4.6 cents a gallon, and 1.7 gallons are required to replace one gallon of gasoline, so there would be a shortfall of .5¢/gal. of methanol, which could cost the Highway Trust Fund $8-30 million. Methanol is on EPA's list of hazardous substances, due to its much higher toxicity than gasoline. Methanol is also dangerous because it burns with a nearly invisible flame, presenting special dangers.[144]

Expansion of ethanol in the form of gasohol is a far more feasible prospect; in fact there is the possibility that its use may be mandated for metropolitan areas that have excessive carbon monoxide levels. Since gasohol enjoys a 6 cents exemption from the Federal tax on gasoline this could cause a substantial drop in Federal Trust Fund revenues, up to $1 billion if all non attainment areas were to switch to gasohol.[145] Currently, this exemption acts as a $25 per barrel subsidy for ethanol production, and a loss of $480 million to the Trust Fund, with state

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[142] CQ, *Congressional Quarterly Weekly Report*, Clean Air Act Amendments, November 24, 1990, p. 3934-3963.

[143] "California Fuel Methanol Cost Study, Executive Summary Volume 1," *Alternative Motor Vehicle Fuels*, Hearing before the Subcommittee on Energy Research and Development, Committee on Energy and Natural Resources, United States Senate, 101st Cong., 1st Sess., June 8, 1989, Washington DC: GPO, 1989, p. 88-103.

[144] "Statement of the American Petroleum Institute," in *The Impact of Air Quality Regulation on Federal Highway and Transit Programs, and on Fuel Tax Collections*, Hearing before the Subcommittee on Investigations and Oversight of the Committee on Public Works and Transportation, House of Representatives, 101st Cong., 1st Sess., Nov. 9, 1989, Washington DC: GPO 1990, p. 202-220.

[145] Justice, Kermit, "Potential Impacts of Pending Clean Air Act Reauthorization Legislation," in *The Impact of Air Quality Regulation on Federal Highway and Transit Programs, and on Fuel Tax Collections*, 1990, p. 135-145.

exemptions costing another $60-240 million.[146]

CNG is likely to dominate methanol in Texas due to safety and infrastructure issues. The increased demand for natural gas due to fleet vehicles would be unlikely to have a significant impact on prices, unless CNG managed to penetrate the private vehicle market. CNG does have higher vehicle cost, slow refueling, and a limited base of technology development for gas-powered vehicles. However on a Btu basis it is cheaper than gasoline, so that CNG can be economic for those uses where range and quick refueling are not particularly important, such as fleet vehicles and buses. This makes it especially attractive for the Houston metropolitan area, which is one of the worst nonattainment areas for ozone and Dallas, also a nonattainment area.[147]

National Security and Oil Imports

The national security aspect of energy consumption is directly related for the need for oil imports to supply motor fuels. There has been a heated debate between energy economists over the value of a reduction in energy imports. The basic argument rests on the cost and benefit of an import fee, but the implication is that there is a social cost to oil consumption which might justify a tax to compensate for this externality.

The basic argument for a tax is similar to the argument for an import tariff since if domestic oil supply is inelastic (which is probably the case within a reasonable range of prices due to exhaustion of the stock of easily discovered large fields,) then an increase in consumption implies an increase in imports. According to Broadman and Hogan, the price the US pays for oil on the world market is affected by the level of US import demand. Optimal tariff theory suggests that by increasing imports we cause an increase in the world price of oil, and on the margin the cost of each additional barrel imported (consumed) is not only its market cost but the increase in cost of our entire volume of imports (an increase in cost of domestic oil is a transfer to producers from consumers, unless there are wasted inputs, and therefore no economic loss). Thus if imports increase from 5 to 6 million barrels per day (bpd), and the price increases from $20 per barrel to $22, the total cost of imports has increased from $100 million per day to $132 million, and the marginal cost of the additional million bpd is $32 per barrel, not $22, and the social cost is $10 per barrel (since they were worth $22 or they would not have been purchased). There can also be an additional cost if the higher oil price results in detrimental macroeconomic performance by the US economy. The key here is the assumption that increased imports (consumption) in the US actually affects the world market, that is, the supply of oil imports is fairly inelastic. If it is price elastic then additional imports will have little impact on the world oil price and therefore no social cost.

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[146] API Statement, 1990

[147] Office of Technology Assessment, *Replacing Gasoline: Alternative Fuels for Light-Duty Vehicles*, September 1990, Washington DC: GPO, 1990.

There is also a security component that reflects the market imperfections associated with the total costs of oil supply disruptions and the risks arising from vulnerability to such disruptions. We could describe this as the Persian Gulf case, in which unexpected events cause a sudden reduction in world supply (since the world market is integrated, the source of oil is only important in terms of refinery efficiency, not oil availability), resulting in price shocks and economic disruptions. Boardman and Hogan calculate that the optimal import fee would be around $11 a barrel (26¢/gallon). The strategic petroleum reserve, since it acts as an insurance policy, is complementary to a tariff, and would lower this fee to some extent.

Other economists argue that changes in oil markets have substantially increased the short-term elasticities of both the supply and demand for crude oil relative to the situation that prevailed in the early 1970s. Given a functioning market, there is no need for insurance against disruptions since speculators are willing to take the risks (inventory holding and liquidation) required to guarantee market clearing. The events in the former Soviet Union lend some support to this theory, since oil is more a source of foreign currency than a tool of international politics. If the supply of oil is elastic, then there will be substantial costs to a security tax (or tariff--the difference involves more who benefits, the government or domestic suppliers) which will be imposed upon consumers without compensatory social benefits.

Unfortunately there is no simple answer to this controversy. In the last few years we have seen a war on the borders of the world's largest oil supplier, and before that there was a decade in which there was a threat on shipping in the Persian Gulf. Given the instability of the region it would be foolish to be complacent about future events. On the other hand, the breakup of the Soviet Union has created strong incentives for rapid expansion of production of one of the world's largest potential reserves of hydrocarbons, but also, the threat of civil war shutting down production in large current producing regions. Therefore arguments that it is prudent to insure against unexpected events cannot be dismissed by referring to some optimization model in which large economic costs accrue from import restraint, since economists are notorious for their inability to account for sudden economic changes arising from political events. In the short run it is easier to dismiss the optimal tariff argument than the security rationale for an oil tax, but given the eventual exhaustion of newly found reserves world oil supply elasticity may decline rapidly in the future.

The careful policy maker would conclude that some restraint in consumption might be in order, with the revenues used to fund an expanded strategic petroleum reserve. However, from the perspective of state taxation it is not economically rational to impose a security fee on oil product consumption since even a state as large as Texas consumes too small a quantity to have a decisive impact on national oil imports. This is a national issue that should not be addressed at the state level.

CHAPTER VIII. PRIVATE FINANCING OF ROADS

In the past, the desire for increased development and the concurrent higher property values led communities into providing incentives for developers not to impose costs upon them. This attitude still holds in areas which are stagnant or growing slowly, where there is a reluctance to take any action which might discourage development on the grounds that it brings jobs and additional tax revenues. Given sufficient infrastructure capacity such that there are low marginal social costs associated with development, this may be a rational course of action. However, rapid growth in many areas such as California, Florida and Texas brought with it the realization that growth often increased costs, both fiscal and social, at a faster rate than the revenues produced by a larger tax base.

The combination of strong growth and increasing congestion are the two factors most likely to spur local government in demanding compensation of some sort for highway costs from new development. A high degree of congestion creates political pressure to spend additional funds on roads, and rapid growth generates pressure to assign these costs to new development, to pay a fair share of the costs imposed upon the general community. At the same time developers are more willing to bear these costs when it is to be spent to reduce congestion on the main arteries serving their property, as this increases the value of their real estate. Rapid growth will create a different type of pressure, with communities split between pro- and anti-growth factions depending on the costs imposed upon existing residents. Land owners usually prefer growth, homeowners can be split depending on whether increasing property values compensate for decreasing amenities of life, while renters are usually opposed since they are hurt the most, afflicted with higher taxes, higher congestion and higher rents. Pro-growth groups may accept fees on development to increase support through the claim that development is "paying its own way," anti-growth groups support development fees because they may slow the rate of growth. Local developers have been among the strongest supporters of impact fees for defensive reasons; they fear moratoriums might be placed on development and that insufficient public facilities might be built to accommodate their subdivisions.[148]

A key factor at the local level will be the political environment of the community. Since voter participation in local politics is limited, access to funds and organization are crucial for political success. Large developers tend to have an advantage in influencing public policy when there is little controversy, since they can afford to invest substantial (relative to the available funds to local politicians) sums in gaining political influence. They also tend to have strong ties with the local business community, which usually encourages development on the grounds that a larger local market is to the benefit of most local businesses, unless a specific development threatens existing economic interests. However, in regions of high growth or when development offends community values (i.e. the Barton Creek controversy in Austin), then citizen groups can play an important role in determining policy, since the organizational difficulties which limit

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[148] Stegman, Michael, "Impact Fees," Transportation Research Circular #311, TRB, National Research Council, Washington D.C, Dec.1986, p.4-14.

public interest groups at the national level are less of a hindrance at the local level. They are usually the primary means by which anti-growth and anti-tax sentiment enters the political debate.

Developers often accept the inevitable when it comes to some form of payment to the local jurisdiction, but they would prefer to have control over the type and timing of their contribution. A developer wants to minimize up-front capital costs by delaying or stretching out payments. He or she would like to limit the financing of improvements to those directly adjacent to the development site, and have other developers and the locality share the cost of off-site improvements. Developers also attempt to control improvements constructed with their money to ensure the maximum return on the expenditure. Developers do not want to be responsible for road maintenance, and would prefer government to accept responsibility for the road.[149]

Traditional private highway financing has included local assessment districts and subdivision exactions. Local assessment districts were formed in many states to fund the construction of roads without burdening the general tax base, as well as to fund sidewalks, curbs and gutters, and minor widening after adjacent property had already been developed. Exactions have been used to obtain funding for facilities that directly serve new development, including such items as subdivision streets, sidewalks, and street lights. Site-related improvements, such as widening adjacent streets, and access improvements, including turn lanes and traffic signals, are generally accepted as being within the bounds of traditional subdivision exactions. In both cases the principle is that funding should be obtained from the immediate beneficiaries of the improvements.[150]

Exactions are rooted in the police power of local governments rather than in the taxing power. They are designed to ensure that necessary improvements will be made in public facilities likely to be overburdened by new development and to ensure that developers cover appropriate portions of the costs to serve that new development. Three major tests have been developed as a way of ensuring that substantive due process concerns are met. The most stringent test requires that exactions be imposed only to satisfy needs that can be specifically attributed to a particular subdivision. The most liberal test allows exactions to be imposed whenever they are rationally related to subdivision-generated burdens or needs. The most commonly applied test, the dual "rational nexus" test requires a "reasonable" basis for concluding that the need for the exaction resulted from the activity of the developer, and that the amount of the exaction bears some relationship to the cost responsibility share of the development. Some courts add an additional requirement that the exaction be reasonably related

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[149] Draper, Robert, "A Closer Look at Impact Fees," *Transportation Research Record* N1107, TRB, National Research Council, Washington D.C., 1987, p. 68-72.

[150] Meisner, L., W. Merrill, S. Connelly & T. Snyder, *Public and Private Partnerships For Financing Highway Improvements*, NCHRP Report 307, TRB, National Research Council, Washington D.C., June 1988.

to benefits that the subdivision will receive.[151]

Land use regulations have become the primary mechanism for extracting payments from developers for the additional congestion created by development. The major types of private funding that have recently evolved or come into increased use include development agreements, special assessment districts, joint ventures, tax increment financing, traffic impact fees, and toll financing. Development agreements usually involve the negotiated dedication of land for right-of-way and the construction or funding of specific highway improvements as a condition for zoning subdivision or building permit approvals. Special assessment districts assess property within a specific area on an annual basis to pay for highway improvements that benefit those properties. Joint ventures include various types of funding involving both public and private funds, usually under a contract among two or more private parties and public agencies. Tax increment financing uses a portion of tax revenues from new growth, usually property taxes above a base level, for street and highway improvements and possibly other infrastructure investments needed to serve the new development. Traffic impact fees are uniform charges imposed on all new development to pay for a portion of those highway improvements needed to serve it.[152]

Development fees, development agreements, and special assessment districts all were seen as ways of transferring the costs incurred by new growth to the new residents or businesses. Thus, when applied to new development only, all of these mechanisms are acceptable to existing residents. Traffic impact fees are more acceptable to most developers than are development agreements, because the fees are predictable and are assessed against all development, not only large projects. Special assessment districts also are favored by developers, but concern has been raised by some citizens who are involved with the future maintenance of district-funded roads.[153]

The use of private funds for highway improvements requires extensive administrative effort and institutional coordination. Reliance on developers to provide highway facilities may result in a jumbled pattern of piecemeal improvements, so it is important to have a master plan developed in conjunction with state authorities to provide a blueprint for utilizing developer contributions. Legal limits to encouragement of developer contributions have not been well established, raising the threat of litigation. There are fiscal limits to developer contributions; single family housing site preparation costs range from $7-12,000 per lot, townhouses $4-7,000, while street costs can range from $3-5,000 per lot, as well as right-of-way and construction to arterial roads and streets. Assigning the full costs of additional highway infrastructure could

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[151] Meisner, 1988.

[152] Meisner, 1988, Schoppert, David & William Herald, "Private Funds for Highway Improvements," *Transportation Research Record* N900, TRB, National Research Council, Washington D.C., 1983, p. 42-47 and Elizer, R. Marshall, "Private-Sector Participation in Transportation Improvements: Survey Results," *ITE Journal*, April; 1988, p. 46-51.

[153] Meisner, 1988, and Schoppert, 1983.

price housing out of reach of working class and even middle class potential homeowners.[154]

The most common joint equity ventures are for parking facilities in high-density developments and other specialized facilities. However, some recent joint venture projects have been concerned with constructing highways that will serve a public need but will also benefit private property. The key characteristics of the joint venture agreement are sharing of costs between the public and private sectors and a true voluntary approach to the project. Tax increment financing (TIF) involves the dedication of a portion of tax revenues from new growth to pay for the infrastructure to supporting the growth by earmarking a portion of new property tax revenues. Thus, TIF is a budgetary technique for allocating public revenues rather than a private financing technique.[155]

Development Agreements

Development agreements usually involve the negotiated dedication of land and facilities by developers, and generally are limited to the financing of facilities for which the need is clearly identified with the new development. A major advantage of development agreements is that significant private-sector financed highway improvements can be negotiated during the approval process for large developments. Development agreements often require improvements to be in place prior to occupancy of the development.[156] The primary disadvantage of development agreements is a lack of equity among developers. Since it is not possible for each developer who creates an incremental need for off-site infrastructure to build an incremental portion of it, communities traditionally have limited off-site exactions to large developers. Developers of large projects tend to be more unhappy with development agreements and other exactions because smaller-scale projects and smaller developers are exempted from having to pay.[157]

The required level of improvements may be determined as much by negotiating ability and political factors as by technical issues. A survey of California jurisdictions found that most public administrators were uncomfortable with negotiated financing programs because of the belief that developers are more skilled at bargaining than planners, public administrators, and public works engineers. Ad hoc negotiations result in inequities because standards and criteria frequently vary over time and different locations. Another limitation of the negotiated programs is that relatively few dollars end up off-site. Over 80 percent of the $180 million in negotiated private contributions in California between 1984 and 1986 for state highway projects went

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[154] Schoppert, David & William Herald, "Private Funds for Highway Improvements," *Transportation Research Record* N900, TRB, National Research Council, Washington D.C., 1983, p. 42-47.

[155] Meisner, 1988.

[156] Meisner, 1988.

[157] Stegman, Michael, "Impact Fees," *Transportation Research Circular* #311, TRB, National Research Council, Washington D.C., Dec. 1986, p. 4-14.

toward improving or building new freeway interchanges adjacent to specific developments. While new interchanges improve access, they do little to augment capacity and may actually reduce it. In general, communities which negotiate exactions have been unable to persuade developers to contribute to projects for which the developers perceive no direct benefit.[158] Negotiated agreements may influence locational decisions if developers know that certain locations will require major off-site improvements as a condition of project approval.[159]

Development agreements involve the least administrative cost of private financing options: staff time to draft and negotiate the agreements, perhaps some legal counsel time to review the agreement, and staff time to follow up with the implementation of agreements. There is uncertainty in many states as to whether adequate authority exists to sustain development agreements. Given that adequate statutory authority exists, a local government that enters into a development agreement must be prepared to comply carefully with the terms of that agreement. Without clear authority, local governments and developers both run considerable risk of costly reliance on an agreement that may be subject to judicial invalidation. Local governments should make opportunities for development agreements available to all interested parties to avoid the charge that they have been provided on a discriminatory basis.[160]

Special Assessment Districts

A special assessment is a charge upon lands deriving a special benefit from some capital improvement, in order to defray the cost of the improvement. The charge generally cannot be for more than the benefit received nor for more than the cost of the improvement. It is sufficiently different from other forms of taxation to be free from constitutional requirements for uniformity of taxation. An ad valorem assessment produces a known income stream over time and thus can be used for funding long-term revenue bonds for major improvements. The maximum assessment is known in advance, and the cost can be financed over time as development proceeds, rather than paid in advance. Special assessments often entail financing arrangements in which a local government initially issues bonds to raise funds for an improvement and is later reimbursed by periodic payments from property owners, secured by liens against the property, providing a useful method of covering improvement costs at a lower interest rate and for making improvements with excess capacity in preparation for subsequent development. Special assessments may only be used in furtherance of a public purpose which justifies government participation. Local governments may be obliged or may find it advisable to contribute some proportion of project costs to ensure that costs of anticipated or general benefits are not improperly allocated to assessed property owners.[161]

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[158] Cervero, Robert, "Paying for Off-Site Road Improvements Through Fees, Assessments, and Negotiations: Lessons From California," *Public Administration Review*, 48(1), Jan/Feb. 1988, p. 534-541.

[159] Meisner, 1988.

[160] Meisner, 1988.

[161] Meisner, 1988.

Special Assessment Districts are authorized in all states either under explicit enabling legislation or state constitutional provisions. The major limitation on special assessments is that they can be used only to finance facilities that provide local benefits, not facilities that provide community-wide benefits. The most widespread use of special financial districts is in Texas, where Municipal Utility Districts (MUDs) are used widely in rapidly growing cities to finance water and sewer facilities, and in 1985 the Texas legislature authorized the use of MUDs to finance roads. In general, the greatest problem in using special districts to finance roads is that it is difficult to establish a district which includes all the beneficiaries of a road while excluding others. In practice special assessment districts are usually proposed and defined by land owners who have agreed on an appropriate area for the proposed project. Special assessment districts usually require legal services to set up the district, including formation of organization, bylaws, elections, and other provisions required by law. Many districts rely on consultants for design and construction services and use existing public tax collection agencies to collect assessments, thereby keeping administration costs low and paid out of revenues collected.[162]

In assessing the obligations of property owners to pay for multi-faceted improvement projects, courts and legislatures in a few states have begun to focus on aggregate system benefits, rather than individual benefits. A number of courts have recently approved assessments against relatively undeveloped properties based upon their highest and best developed use. Alternative methods for allocating costs include basing them on the anticipated increase in vehicular traffic generated by the particular property. Finally, a few jurisdictions have developed ordinances that allocate cost on the basis of several factors such as front footage, per lot unit, and zoning use of the property.[163]

Impact Fees

Many areas that have relied heavily on exactions and negotiated agreements have modified them into a more formal system of development or traffic impact fees. Development or impact fees are charges imposed on new development to pay for the portion of public facilities needed to serve it, including large scale, centralized facilities such as arterial roads. Traffic impact fees are probably the most expensive funding mechanism to establish but are relatively easy to administer once determined because they are collected from one individual at one time. First, a detailed transportation study is needed to determine future needs, existing deficiencies, and the costs of accommodating traffic generated by new development. The cost of this study could be minimized if it is coordinated with state or regional transportation planning efforts. Further study is then needed to allocate estimated future costs to development on a per-unit basis. Most jurisdictions assign a cost per generated trip and publish a table of costs per dwelling unit, square foot, or other readily accessible unit for various types of land use. Traffic impact fees also require legal counsel for preparation of an ordinance that will withstand

[162] Meisner, 1988.

[163] Meisner, 1988.

challenges as well as the cost of defending possible challenges. Administering the fee system on a continuing basis can be costly because fees must go into a separate fund, to be used within a specified period for certain types of projects in specific locations. As a form of user charge, they can impose a degree of market discipline on development, but impact fees do not encourage efficient provision of transportation facilities when fees must be spent in certain zones within a specific period, when efficiency considerations would dictate allocation of resources in other areas.[164]

Impact fees have been challenged constitutionally on the basis of equal protection, however, courts have usually not accepted the argument that because developments prior to the imposition of the fee did not have to pay their fair share of road costs, its imposition is a violation of the equal protection clause.[165] A major legal concern is the derivation of costs directly linked to the traffic associated with a project, since developers may challenge fees they consider excessive. To avoid lengthy equity disputes, most communities apply impact fees that recover only a portion of the calculated cost, since a conservative approach may reduce the risk of litigation. Traffic impact fees are politically acceptable because the fees are perceived as being imposed on new residents and businesses. They are equitable across all types and sizes of development and so are favored by most developers over negotiated agreements or controls on growth. They are also known in advance and can be included in the financial feasibility studies for development projects. Because the impact fees are based on uncertain development activity occurring over time, they are not reliable as a source of bonding revenue.

A threshold legal issue is whether the impact fee ordinance represents a legitimate exercise of the police power (similar to exactions), or whether the ordinance constitutes an illegal tax imposed on the few for the benefit of the many. In general, the Courts have articulated a three-part test that embellishes the traditional need-benefit rational nexus analysis: impact fees may be imposed where (1) new development requires that the present system of public facilities be expanded, (2) the fees imposed are no more than what the local government unit would incur in accommodating the new users of a facility system, and (3) the fees are expressly earmarked for the capital projects for which they were charged. Impact fees must be ear-marked to benefit the development charged. Fees must be expended pursuant to a specific plan, with a reasonable period of time, for improvements designed to benefit the areas assessed. New Jersey and Texas appear to be the only states with express state-wide enabling legislation for impact fees.[166]

A fee on new development for road improvements is often viewed as a double payment, because new residents will pay gas taxes, property taxes, and other taxes used to improve and

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[164] Meisner, 1988, and Sandler, R. and E. Denham, "Transportation Impact Fees: The Florida Experience," *Transportation Research Record* N1077, TRB, National Research Council, Washington D.C., 1986, p. 27-31.

[165] Moore, William and Thomas Muller, "Developing Defensible Transportation Impact Fees, *Transportation Research Record* N1283, TRB, National Research Council, Washington D.C., 1990, p. 39-44.

[166] Meisner, 1988, and Sandler 1986.

maintain the highway system as well as the fees on new development. The impact fee pays the capital cost incurred by new development in a specific region; the federal and state fees collected from people driving to and from the new development are no different than that paid by all drivers in the region, and are used to construct and maintain the entire road system, including the newly built or expanded roads. Given that the new construction will have lower maintenance costs than existing roads, one could attempt to calculate the discounted savings between the pro-rata share of community maintenance and the lower cost of maintenance on the new roads, but this difference would be a small fraction of the fee and probably not worth the effort to determine. New residents receive the same benefits as existing residents from the highway system as a whole and should pay the same taxes to help maintain it. There is no reason for the existing residents of a region to subsidize the marginal cost of capital needed to provide services to newcomers.

The first step in the calculation of benefits is to establish current level of service (LOS) standards as benchmarks, either through rule-of-thumb methods or more sophisticated analyses. If the analysis finds that a group of likely developments over an extended time period will cause the LOS to be exceeded, a set of benefit calculations have to be initiated to establish that the impact fee meets legal, equity, and other criteria. In Colorado most jurisdictions imposing fees required traffic studies to contain a core of basic information including site traffic volumes, trip generation rates, trip distribution estimates, signalization requirements, and level-of-service estimates.[167] Given this type of data collection, the state DOT could develop models which could be applied by local communities for these calculations, allowing coordination between the state and localities in road planning simultaneous with calculations of traffic impact costs.

The most obvious method for benefit calculation would be a model in which the costs of current traffic patterns are estimated over a set time period. One would then identify location, type, and size of potential developments over a specified planning horizon, and use this data to determine required improvements, forecast future traffic, needed added capacity, and the cost of improvements. Traffic generated at and attracted to each development site is estimated and distributed to origins and destinations. Traffic is assigned to all routes in the network and improvements designed for links or intersections on which projected service falls below a specified minimum level. Costs which can be assigned to a specific site are attributed to the specific developer. Remaining costs are allocated to developers, prorated in proportion to the amount of traffic from each development using the link in question, and costs are aggregated for each link for each development. One problem is that the process is sensitive to the technique used to assign traffic to the network. Another problem is that route choice for new traffic is often ambiguous, making assignment of traffic flows somewhat arbitrary.[168]

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[167] Colorado/Wyoming Section of ITE, "Survey of Current Practice for Identifying and Mitigating Traffic Impacts," *ITE Journal*, May 1987, p. 38-44.

[168] McNeil, S., T. Rossi and C. Hendrickson, "Impact Fee Assessment Using Highway Cost Allocation Methods", *Transportation Research Record* N1107, TRB, National Research Council, Washington D.C., 1987, p. 73-80.

One advantage of a state wide set of models is that various types of development could then be added to the models; new traffic patterns simulated and the additional expenditures needed to maintain a desired level of service could be calculated, without requiring each community to possess a high level of analytical sophistication. A rough estimate of the traffic impact cost of small scale development could then be determined and used to establish a schedule of fees for the area, since it would probably not be cost effective to make model runs for every possible land use. Large scale developments could be modeled when proposed, and the fees developed along with specific roadway requirements. This could lead to a more consistent method statewide for determining impact fees. Negotiations with developers could lead to construction needed in the short-run, and the cost deducted from their total fees. Having state transportation planners working with local jurisdictions and developers would avoid the piecemeal road building problem and encourage more coordination between local transportation planning and the state highway system.

The more specific the model to the region, and the more detailed the data, the more likely the fee will be upheld in court. One problem with using general data on trip generation (such as ITE calculations) is that these can differ substantially from local surveys. Most jurisdictions used standard references in conducting the traffic impact study, usually ITE's Trip Generation. Most impact fees mentioned in the survey were based on a per unit charge.[169] A study in Montgomery County Md. found that traffic mean trip generation rates reported by ITE were in some cases 40 percent more than rates based on an internal study.[170] Once the basis for estimating the number of trips and their length is determined, care must be taken to avoid the likelihood of double counting, and inclusion of pre-existing trips.

There are a number of different approaches to developing and implementing impact fees. Palm Beach County, Florida, enacted an ordinance in 1979 that established a system of transportation impact fees that are based on trip generation by type of land use activity, the cost of constructing additional highway lanes, and lane capacity. The collected funds are deposited in the trust fund of one of 40 designated impact zones and can only be used for the purpose of constructing or improving roads and bridges on the major road network system. The county encourages developers to make road improvements themselves, which are fully credited against the impact fee. Empirical estimates of the fee's incidence suggest the buyer-occupant would probably bear most of the tax burden, which in Palm Beach would be $600 of the $804 single family dwelling fee. Fees currently collected in Florida are generally less than 1 percent of the development cost and thus are too low to affect location decisions, even if the structure of fees were allowed to vary across a community.[171]

Broward, Florida also began charging impact fees in 1979, with a revision in 1981 leading to employment of a Traffic Review and Impact Planning System (TRIPS) which has

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[169] Colorado/Wyoming Section of ITE, 1987.

[170] Moore, 1990.

[171] Sandler, 1986.

never been challenged in court. Road impact fees are calculated by the TRIPS model. The location, type and magnitude of the proposed development is entered and the model estimates the number of trips, simulates where they will go in the county and which roads they will use. Once the traffic impact is determined the model calculates costs only on road segments which are over-capacity and for which improvements have been planned in the Broward County Year 2000 transportation plan. One result is that it encourages development in areas with adequate roads by charging far higher fees in areas which have higher costs. The program was run on a minicomputer at a cost of $75 per development.[172]

The two general approaches for setting fees in California were an "average" or an "extra" cost basis. Average cost involves some method of estimating the cost of all improvements needed to buildout within a designated area and of apportioning that cost as evenly as possible among all current and future development. The extra cost approach, on the other hand, attempts to base each developer's fee on the cost associated with mitigating the impacts of his or her particular development. Average cost was the dominant choice among cities, while counties tended to use the extra cost method. Most communities charged only a fraction of the cost of highway improvements, compared to the success that Los Angeles and San Francisco have in persuading developers to pay the full cost of off site improvements. The flat-fee per unit approach seemed to be the most politically acceptable and the easiest type of fee program to establish.[173]

Montgomery County Md. development impact fees were imposed in the spring of 1986, and a set fee was determined for each type of unit, single and multi-family residential, office, retail, industrial and various other types of construction. Two schedules were established for different parts of the county, and fees were to be recalculated every two years. The technique used to apportion costs between the private sector and government in an impact fee area is the ratio of the remaining development that can be permitted under the master plan to the total development at build-out, with an upper limit of 50% private financing. There are three major components in the impact fee calculus: the cost of the improvements in the impact fee program, the amount of development remaining to build-out in each land use category, and the relative traffic impact of each category.[174]

Toll Roads

In 1987, net toll mileage in the United States included 2,447 miles of Interstate Highways, 730 miles of Federal Aid Primary, 1,275 miles of other state highways, and a total

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[172] Thompson, Gerald, "Road Impact Fees In Broward County," *Transportation Research Circular* #311, TRB, National Research Council, Washington D.C., Dec. 1986, p. 15-21.

[173] Cervero, Robert, "Paying for Off-Site Road Improvements Through Fees, Assessments, and Negotiations: Lessons From California," *Public Administration Review*, 48(1), Jan/Feb. 1988, p. 534-541.

[174] Orlin, Glenn, "Development Impact Fees and the Growth Management Process," *Transportation Research Circular* #311, TRB, National Research Council, Washington D.C., Dec. 1986, p. 22-29.

of 4,692 miles.[175] Despite the effects of the 1956 Federal-Aid Highway Act, which discouraged the user-fee concept for highways, 20 new toll roads totaling 770 miles and 13 new toll bridges became operational in the United States between 1968 and 1981. After a flurry of activity during the 1950s and 1960s, the addition of new toll road mileage across the country has been slow. The Cimarron Turnpike in Oklahoma was opened to traffic in 1975, Dulles Toll Road in 1984, and the Sawgrass Expressway in Broward County, Florida, in 1986. The Dallas North Tollway in Dallas and the Hardy Toll Road and the Sam Houston Tollway in Houston are examples of important urban freeways that have been built as toll roads in Texas. The Dallas North Toll Road has for several years been used as a prime example of the successful use of an automatic payment system, and a similar system has recently been added in Houston. Very few self-sustaining major new toll bridges have been constructed over the past decade; the last was the Houston Ship Channel Bridge, for which a revenue bond issue of $102 million was sold in July 1978.[176]

Looking back on the success or failure of toll facilities, the conclusion must be drawn that such projects have proven to be viable. Of the great number of projects financed during the modern-day toll era, only three major facilities have defaulted. Recent financing of major toll roads included a new $547.5 million issue by Harris County, Texas in 1985. The county, which encompasses Houston, approved by referendum in 1983 a program to issue up to $900 million in general obligation and revenue bonds for design and construction of the Hardy and West Belt Toll Roads. For the two projects in question--the Hardy Toll Road and the West Belt Toll Road--the county has departed from the otherwise standard practice of relying solely on toll revenues by issuing tax-supported bonds to cover early project costs during design and construction. Additional toll-backed revenue bonds have been issued in several series and are being tapped as necessary to cover the completion costs of the two projects. It is intended that toll revenues will cover the debt service on both series of bonds. The two Harris County toll road projects are being sponsored by the Harris County Toll Road Authority. The projects are not responsibilities of either the state of Texas, the city of Houston, or Harris county itself. Aside from the normal purchasers of rated, tax-exempt debt, there is no private sector capital at risk in these projects.[177]

Historically, tolls could not be charged on highways built with Federal aid until the Federal aid was fully repaid. The exceptions permitting the mix of federal-aid and toll financing have arisen from recognition of the benefits of an integrated, well-maintained highway network, whether or not it is completely toll free. The first type of exception, granted in the Oldfield Act of 1927, permitted federal-aid funds to be used in the construction of toll bridges and approaches

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[175] U.S. Department of Transportation, Toll Facilities in the United States, Washington, D.C., U.S. Government Printing Office, 1987.

[176] Smith, W. & N. Wuestefeld, "Current Trends in Toll Financing," *Transportation Research Record* N900, TRB, National Research Council, Washington D.C., 1983, p. 63-69.

[177] Smith, 1983, and Schaevitz, Robert, "Private Sector Role in US Toll Road Financing--Issues and Outlook," *Transportation Research Record* N1197, TRB, National Research Council, Washington D.C., 1989, p. 1-8..

on the federal-aid highway system. The second and third exceptions, contained in the Federal-Aid Highway Act of 1956, permitted the use of federal aid to construct approaches to toll roads on the Interstate system and incorporated approximately 2,500 miles of existing toll roads into the proposed Interstate system. To receive federal funds, the states must agree to make the toll facilities free to public travel upon collection of tolls sufficient to retire the indebtedness of these facilities. Section 105 of the Surface Transportation Assistance Act of 1978 authorized the use of Federal Interstate 4R funds on Interstate system toll roads contingent on pledges to remove the tolls when the bonded debt is retired. Congress has periodically allowed states to repay federal aid expended to build or partly build a highway so that tolls may be imposed. There have been at least five cases of such highways, each less than 50 miles long. Few routes carry sufficient traffic volumes to cover the total costs of toll road conversion and operation if full federal-aid payback is required, since the federal policy mandating full payback imposes a financial cost on the state for physical resources that have limited economic value due to deterioration.[178] The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) provided many states with more flexibility in their highway financing programs, introducing important changes to the use of tolls on Federal-aid facilities. It authorized Federal participation in 1) the reconstruction and conversion to toll of free highways (except for Interstate roads) and free bridges and tunnels, 2) 4R work on toll facilities, 3) initial construction of toll facilities (except for Interstate), and 4) preliminary studies to determine the feasibility of a toll facility for which Federal participation is allowed. Furthermore, under the ISTEA private entities may own toll facilities and public authorities are then responsible to ensure compliance with all the requirements of Title 23. Also, the Federal-aid share in constructing, reconstructing, resurfacing, restoring, and rehabilitating a toll facility varies by project type. The state is allowed to loan the Federal share to another private or public entity constructing the project. Repayment of the loan may be used for transportation purposes under Title 23. Table 8-1 provides a summary of the Federal-aid share by type of work. As for toll revenues received from operating the toll facility, the ISTEA stipulates they must first be used for debt service, for reasonable return on investment, and for covering operation and maintenance costs of the facility. Toll revenues in excess of these requirements must be used for transportation purposes under Title 23.[179]

There are no major toll roads still in private ownership. Where it was once possible to establish financial feasibility for a toll road with average daily traffic of only 20,000 vehicle trips, modern facilities can require as many as 100,000 daily vehicle trips and more before meeting debt service coverage and O&M costs. The increased traffic requirement is the combined result of higher construction and maintenance costs and the presence of many more

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[178] Smith 1983, Wuestefeld, Norman, "Toll Roads," *Transportation Quarterly*, 42 (1), Jan. 1988, p. 5-22 and Gittings, Gary, "Some Financial, Economics, and Social Policy Issues Associated With Toll Finance," *Transportation Research Record* N1107, TRB, National Research Council, Washington D.C., 1987, p. 20-30.

[179] U.S Department of Transportation, Federal Highway Administration, "Exploring Key Issues in Public-Private Partnerships for Highway Development", Searching for Solutions, *A Policy Discussion Series*, Number 2, June 1992.

Table 8-1. **Federal-aid Share for Activities Eligible for Toll Financing and Public-Private Partnerships**

Activities Eligible for Toll Financing and Public-Private Partnerships	**Federal-aid Share (percent)**			
	Interstate		**Non-Interstate**	
	Roads	**Bridges/ Tunnels**	**Roads**	**Bridges/ Tunnels**
Initial construction (except in the Interstate System) of a toll highway, bridge, tunnel, or approach thereto	NA	NA	50	80
Reconstruction of an existing toll highway, bridge, runnel, or approach*	50	80	50	80
Resurfacing, restoring, and rehabilitating of a toll highway,bridge, tunnel, or approach*	50	50	50	50
Reconstruction or replacement of a free (non-Interstate) highway, or a toll free bridge or tunnel on or off the interstate, and conversion to a toll facility	NA	80	50	80
Preliminary studies to determine the feasibility of the aforementioned toll construction activities	50	50	50	50

*Note that an exception to the 50 percent share is that highway facilities under existing Federal toll agreements are eligible for 80 percent Federal-aid share until the expiration of the existing toll agreement.

Source: U.S. Department of Transportation, Federal Highway Administration, "Exploring Key Issues in Public-Private Partnerships for Highway Development", Searching for Solutions, *A Policy Discussion Series*, Number 2, June 1992.

competitive free highways limiting toll revenues. This relationship, in addition to limiting new toll roads to urban areas with high traffic volumes, is helping to motivate the search for extended revenue packages, new sources of debt security, and more direct private sector roles and responsibilities.[180]

There are a number of advantages to toll projects over conventional government financed highway construction. Tolls provide the most precise form of pay-as-you-go financing. Toll projects can be implemented quicker than tax supported projects because complete funding is available at the beginning of a project; toll projects do not always have to comply with federal statutes, standards and regulations; and there is usually no need to go through a review process by federal and state agencies. Toll financing requires the provision of adequate funds for inspection, maintenance, and operation as part of the agreement with bondholders, and toll

[180] Schaevitz, 1989.

facilities implemented using revenue bonds, are subject to close scrutiny prior to financing. This includes the cost of construction and right-of-way, and maintaining and operating the facility. A final advantage is that toll collection can be used as a method of congestion pricing, encouraging users to make more efficient route or mode choices. Rates per mile for existing turnpikes range from 1.56 to 3.11¢/mile for autos and 6.65-9.73¢/mile for five axle trucks, which fall in the range of proposed congestion fees.[181]

The disadvantage of toll financing is the higher costs associated with all current system of toll collections, though these costs could be reduced through Automatic Vehicle Identification in the future. There are private and social costs associated with toll collection, including the time delay when motorists are stopped in a queue to pay their toll, costs to users diverted to alternative routes, indirect costs imposed by diverted traffic to users of alternative routes, and decreased air quality and increased fuel consumption. By their nature, toll roads usually have less frequent access than tax-supported expressways, thereby decreasing development opportunities in the toll road corridor. The greatest problem is the cost of constructing and operating the toll collection facilities. On the Dallas North Tollway Extension and Hardy Toll Road, currently under construction, these costs represent 1.9 and 2.8 percent of total right-of-way and construction. Toll collection is labor intensive with labor costs accounting for as much as 80 percent of total collection expenses on closed ticket systems. A 1983 study indicated the total cost of toll collection averaged about 18 percent of gross toll revenues, compared to 1 percent of gross revenues for collection of motor-fuel taxes. In 1985 the Pennsylvania Turnpike toll collection cost 14.8 percent of revenues; New York State Thruway 16 percent, and the New Jersey Turnpike 19 percent, not including toll collection area maintenance expenses.[182]

There are three traditional systems of toll collection, ticket, mainline/ramp and mainline barrier. In a ticket system of collection, a ticket is received upon entry and is surrendered with payment, when leaving, limiting access to toll-paying motorists. Toll booths are located at each point of entry and exit, and main-line barriers span the roadway at each end of the toll route. The mainline barrier-only system permits toll-free travel among interchanges located between the mainline barriers. A third alternative design, the mainline/ramp barrier system (M/RB) is a hybrid of the other two systems and the most commonly used today; no new ticket system toll roads have been introduced during the past few decades. If designed as a closed system, toll barriers are located at intervals along the main line and most interchange ramps also contain toll booths. Open barrier-ramp systems allow the flow of some toll-free traffic, with main-line toll barriers and tollbooths on selected high-revenue interchange ramps and toll-free passage between certain contiguous interchanges. In terms of the incremental cost principle, closed systems are inherently more equitable because their charges are based on each increment of road service consumed.[183]

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[181] Wuestefeld, 1988.

[182] Wuestefeld, 1988, and Gittings, 1987.

[183] Wuestefeld, 1988, and Gittings, 1987.

The high density of interchanges coupled with the need for collection facilities at each entry and exit point makes the cost of converting existing nontoll, limited-access highways to closed-system toll roads extremely expensive, both in terms of the capital costs to adapt each interchange to facilitate toll collection and in terms of operating and maintaining the many toll collection points. Closing an interchange can impose significant changes in travel patterns and social interactions. Objections are likely to arise from motorists who are frequent users of the interchange, from nearby business and commercial establishments, and from the community in general if there is a perception that the change in accessibility is a threat to community safety.[184]

A previously authorized federal surface transportation program contained provisions for the use of federal highway funds in conjunction with toll-financed projects. In that pilot program, federal contributions were limited to 35 percent of the total cost of the project, applied to eight projects in eight designated states. Texas selected the Sam Houston Tollway-East as its project. This 30-mile project is part of an outer belt roadway that will encircle the Houston CBD at an approximate radius of 12 miles. However, the tollway feasibility study, completed in the summer of 1990, showed that projected toll revenue would be insufficient to cover the state's costs on the entire 30-mile segment, as only a 14 mile, four-lane segment between interstate Highway 10 and Interstate 45 to the east of Houston, which incorporates the Jesse Jones Bridge, would generate the required 65-percent share necessary under the pilot project. Texas law requires that toll revenues cover all state costs and that no state tax money be used for toll projects, limiting the project to this stretch of road. The Turnpike Authority plans to use an AVI system on the toll road, as well as a combination of manual and automatic coin collection systems.[185]

The recently enacted Intermodal Surface Transportaion Efficiency Act of 1991, in Section 1012 entitled "Toll Roads, Bridges, and Tunnels," permits federal participation in the following categories: (1) initial construction of a toll facility; (2) reconstruction of an existing toll facility; (3) reconstruction of a toll-free facility and conversion to a toll facility; and (4) preliminary study to determine the feasibility of a toll facility. A toll facility that is constructed must be publicly owned or be privately owned if the public authority having jurisdiction over the facility has entered into a contract with a private person or persons to design, finance, construct, and operate the facility. The public authority will be responsible for complying with all applicable requirements with respect to the facility. The public authority including the state DOT must agree with U.S. DOT that all toll revenues received from operation of the toll facility will be used first for debt service and for the costs necessary for the proper operation and maintenance of the toll facility. The state may use excess toll revenues for any purpose if the state certifies annually that the tolled facility is being adequately maintained. The federal share payable for construction of a highway, bridge, tunnel, or approach thereto, or conversion of such facilities to toll facilities, shall not exceed 50 percent. This new legislation has not had the anticipated

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[184] Gittings, 1987

[185] GAO, *Highway Financing: Participating States Benefit Under Toll Facilities Pilot Program*, US General Accounting Office, Report to Congressional Requesters, RCED-91-46, December 17, 1990 and Schaevitz 1989.

impact to date but opens many new possibilities.

State of the art automated vehicle identification equipment has shown that it can reduce congestion associated with toll collection. In reviewing its toll collection options, Georgia reported that AVI should not only expedite toll collection but also reduce operating costs. Texas is using an AVI system in conjunction with its manual collections system on the Dallas North Tollway portion of its turnpike system. The turnpike authority fully implemented the system in July 1989, after a successful testing period. The $4 million AVI system was installed and is managed by the manufacturer at no cost to the state. Users establish an account with a $40 balance and receive a computer chip to place inside the car windshield. As the user goes through a toll plaza, radio-frequency broadcasting and reception equipment reads the chip and debits the account for the toll charge plus a 5-cent service fee, and a $2 system access fee each month. As of January 15, 1990, according to AVI vender officials, the system had not misread a tag on the Tollway in over 2 million transactions. With dedicated lanes, AVI vehicles do not have to slow down and intermingle with other traffic to go through the plaza since the equipment can read the computer chip at speeds of up to 180 miles per hour. AVI transactions represented about 20 percent of the toll transactions on the Tollway as of November 1990, but 41 percent of the rush-hour traffic was using the system. About 17,000 chips were sold in the first 7 months of operations.[186]

Privatization of Roads

It has been suggested by some observers that it would be desirable to completely privatize part of the highway system. Among the arguments presented for this position is that revenues might be raised without increasing taxes, efficiency of highway usage might be improved as private owners would have no political constraints preventing efficient pricing, and production efficiency and quality might improve under private ownership. Private companies have profit-maximization incentives to minimize production costs, implying that private highway companies would be at least as efficient as the government, if not more efficient, especially over the long run. It is less reasonable to assume that a government owner would adopt the construction and maintenance policies which maximize welfare given the numerous constraints, legal, political, and otherwise which can cause policies to diverge from economic efficiency. Private highway owners would probably bring a more vigorous and innovative approach to managing traffic flow and servicing their traveling customers.[187]

Highway supply cannot be perfectly competitive because no two highways would be

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[186] GAO, 1990.

[187] Geltner, D. and F. Moavenzadeh, "An Economic Argument for Privatization of Highway Ownership," *Transportation Research Record* N1107, TRB, National Research Council, Washington D.C., 1987, p. 14-20 and Geltner, D. & R. Ramaswamy, "Economic Efficiency Implications of Optimal Highway Maintenance Policies for Private Versus Public Highway Owners," *Transportation Research Record* N1116, TRB, National Research Council, Washington D.C., 1987, p. 22-30.

perfect substitutes due to geographic uniqueness, thus, private highways would have market power. It can also be shown that the highway owner will under invest in quality in this circumstance. When the private owner of the highway also owns major real estate parcels served by the highway, the external benefit of improved highway quality would be to some extent internalized by the highway owner because the value of the owner's real estate is improved by the quality of the access to it. The main potential economic benefit from highway privatization might be to improve the production efficiency as opposed to allocational efficiency with which highway quantity and quality are produced. Unless private roads can be regulated or controlled efficiently, these benefits will not be worth the likely loss in allocative efficiency associated with excessive tolls and suboptimal highway quality, which private highway owners would provide due to highway market imperfections. The maximum toll could be prescribed as part of the bidding process in the sale of the highway, the same for the level of quality. An alternative is a quality subsidy to maintain it at the socially optimal level.[188]

[188] Geltner, 1987, and Geltner, 1987.

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CHAPTER IX. FEDERAL, STATE, AND LOCAL TAXATION

Overview

The data presented in Table 9-1 provides an overview of the ten states that spent a total of least two billion dollars in 1990 for all roads and highways (New Jersey, although it has expenditures on a similar scale, was not included on the grounds of its relatively small geographic area). These states contain almost half of the country's population, and most of its major cities. These states are characterized by large populations, extensive road systems, and a mix of urban and rural populations. They share with Texas the problems of funding and maintaining a major transportation infrastructure system on a scale that exceeds the highway capacity of most countries.

California has the highest total demand for highways, while Texans and Virginians drive the most per capita. New York has the lowest rate of travel per capita, due to the availability of mass transit combined with high costs of driving in New York City. While it is not surprising that California has the highest proportion of urban driving, Florida and Texas drivers also proportionally drive more on urban roads than in most states, suggesting the importance of urban sprawl in determining driving patterns. Interstates account for about one-quarter of the nation's vehicle miles, while federal aid is available for roads on which 80 percent of travel occurs. Texas has the most state road mileage, followed by Virginia (all roads except for two counties are state roads) and Pennsylvania. Not surprisingly, California has the most highly congested road mileage. Highways in Florida and Virginia are in the best shape, while Pennsylvania, Michigan and Minnesota have the lowest proportion of roads in good or excellent condition.

The 1980s were a difficult time for state governments due to a decline in federal resources transferred to states without a concurrent diminishment of mandated responsibilities. Local and state taxes as a fraction of personal income peaked at 12 percent in 1977-78, when the passage of Proposition 13 in California discouraged politicians across the nation from proposing further tax increases and Carter reversed the long-term increase in federal aid to state and local governments. By 1982 local taxes had decreased to 10.6 percent of income before rising back to 11.6 percent by 1989. Federal aid peaked at 4.3 percent of taxpayer income in 1978 and declined by a full percentage point over the next decade. States responded by cutting spending for a few years, primarily welfare and highways, while local government discovered various user charges. State highway spending as a percent of income declined from .83 in 1976 to .59 in 1984 before rebounding to .66 in 1988. Motor fuel taxes which had lagged behind other state taxes during the 1970s were increased to fund the backlog of highway projects which had developed during years of neglect.[189]

[189] Gold, Steven, "Changes in State Government Finances in the 1980s," *National Tax Journal*, 44(1), March 1991, p. 1-19.

Table 9-1. Overview of the Ten Major Highway User States

State	Population (1000)	VMT (Mil.)	VMT per Capita	%VMT Urban	%VMT Interstate	%VMT Federal Aid
California	29,760	258,926	8,700	78.9	25.5	89.3
Florida	12,938	109,997	8,502	70.9	17.5	70.0
Illinois	11,431	83,334	7,290	68.6	25.4	85.5
Michigan	9,295	81,091	8,724	59.9	20.9	86.7
Minnesota	4,375	38,946	8,902	51.9	20.0	78.5
New York	17,990	106,992	5,947	70.6	18.3	82.8
Ohio	10,847	86,972	8,018	59.0	27.1	78.8
Pennsylvania	11,882	85,708	7,213	54.6	17.6	83.7
Virginia	6,187	60,178	9,726	53.4	25.1	83.5
Texas	16,987	162,232	9,550	66.3	21.4	71.4
Nation	248,709	2,147,501	8,635	59.5	22.3	80.7

State	State Miles	% of Total	%Total VMT	V/C >.8 Urban Miles	V/C >.7 Rural Miles	% of Hwys. Rural	PSR >3 Urbn.
California	15,169	9.0	53.0	3,977	1,537	55.4	39.5
Florida	11,801	10.9	62.9	440	163	78.7	76.9
Illinois	17,176	12.5	66.0	1,254	36	46.7	46.2
Michigan	9,540	8.0	54.0	1,100	555	33.9	35.3
Minnesota	12,100	9.0	58.0	283	228	29.8	33.4
New York	15,660	14.0	60.0	1,809	482	55.7	58.4
Ohio	19,460	17.0	74.0	1,061	341	54.1	30.5
Pennsylvania	41,091	35.0	86.0	1,207	411	30.8	25.0
Virginia	54,584	86.0	91.0	515	348	62.3	61.4
Texas	76,564	25.0	66.0	1,574	221	48.1	44.4
Nation	766,353	19.8	67.5	22,980	9,956	50.9	48.3

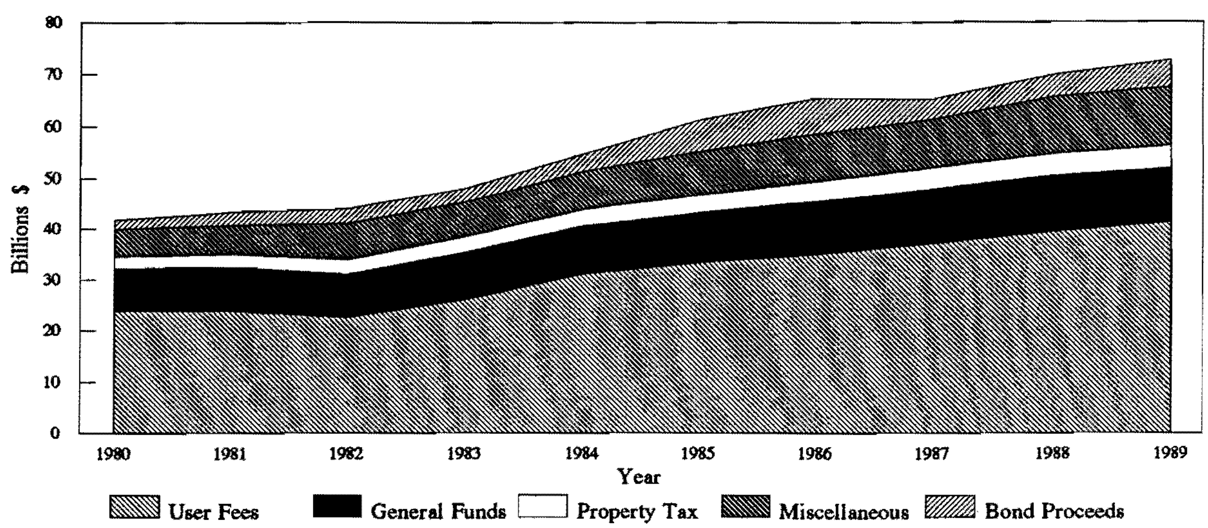
Source: *Highway Statistics, 1981-1990.*

Highway Finance Trends

During the 1980s demands on the nation's highways increased at a faster rate than funding for construction and maintenance. Freight traffic grew at 3.0 percent annually from 1980 to 1988, while passenger travel increased by 2.5 percent per annum over the same period, but the real value of highway funds increased at only 1.4 percent per year, and the result was the gradual deterioration of the nation's highway infrastructure. Almost all categories of roads, Interstates, arterial road systems and collector roads (except rural collectors which improved during the period) were gradually deteriorating from good to fair condition according to AASHTO engineering standards. Toward the end of the decade, with the federal government reluctant to increase aid in the face of a growing budget deficit, the states took the initiative in raising additional funds for roads.

The primary source of funds for roads, as can be seen in Figure 9-1, is user fees, primarily motor fuel taxes and motor vehicle fees. General funds are a secondary source along with a variety of minor fees and charges (lumped under miscellaneous), with bonds and property taxes a minor source of funding. There has been little change in the composition of revenues available for state highway programs over the last decade, with federal funding declining slightly in importance, replaced by a greater dependence on user fees.

While federal aid has remained about one-third of all funds used for road building and maintenance, states have relied on an equal mix of fuel taxes and a heterogeneous bundle of various taxes and fees. Licenses and vehicles registration are important sources of funds in many states, but a number of states have employed taxes on vehicle parts, various fees on trucks from tire taxes to weight-distance taxes, tolls, fines and special use taxes. Most states tend to dedicate funds raised for transportation, but some states use general funds for a significant portion of their transportation budget, creating additional uncertainty in budgeting. The use of bonds is less common than one would expect for financing what is partially a capital investment, as constitutional issues or fear of debt inhibit the use of this financial instrument. Table 9-2 shows different highway revenue sources as percentages of total revenues for the years 1981 and 1985 through 1990, for all states combined.



Source: Highway Statistics, 1981-1990.

Figure 9-1. Revenue Sources For Highways: All Levels of Government 1980-1989.

Table 9-2. State Highway Revenue Sources 1981-1990 (%)

	1981	1985	1986	1987	1988	1989	1990
User Fees	51.1	48.7	48.4	52.5	52.7	51.3	54.4
Tolls	4.9	4.5	4.6	4.9	5.0	4.9	5.0
General Funds	3.3	2.3	2.2	2.6	2.1	3.0	3.0
Other	6.7	5.8	6.4	6.3	6.3	6.9	7.4
Federal Funds	29.9	29.9	29.0	28.8	28.7	26.6	27.5
Bonds	3.2	7.8	8.6	4.1	4.3	5.9	1.3
Total ($million)	29,094	43,746	45,861	46,363	46,802	51,215	53,851
Total (1990$)	41,631	52,319	53,434	52,344	50,856	53,341	53,851

Source: *Highway Statistics, 1981-1990* (based on tables SF-21). GDP deflator used to calculate 1990$.

Table 9-3. State Highway Funding Sources: Ten Major States 1990 (%)

State	Federal Aid	Fuel Taxes	Vehicle Fees	Tolls	Other	General Funds	Local Funds	Bonds	Total (Mil. $)
California	37.3	29.1	21.7	2.4	6.6	0.0	3.0	0.0	4,080
Florida	22.8	29.1	15.5	6.2	8.2	0.0	0.6	17.6	2,061
Illinois	18.2	37.8	18.6	8.8	5.3	5.6	1.1	4.5	2,719
Michigan	21.8	40.9	25.2	0.9	4.8	4.7	1.7	0.0	1,491
Minnesota	21.8	36.1	26.9	0.0	10.1	2.3	2.4	0.4	1,241
New York	21.1	18.3	13.4	17.6	5.7	2.0	0.0	21.9	2,838
Ohio	18.1	43.5	21.1	3.6	2.8	6.2	1.4	3.3	2,313
Pennsylvania	27.3	35.5	19.1	10.1	4.9	0.0	0.8	2.2	2,835
Virginia	17.9	34.0	19.0	5.2	16.3	4.6	3.0	0.0	1,801
Texas	35.2	32.9	22.2	1.3	3.2	0.0	1.3	4.0	3,181

Source: *Highway Statistics, 1990* (based on table SF-21).

Table 9-4. **Local Highway Funding Sources: Ten Major States 1990 (%)**

State	Property Taxes	Local User Fees	Tolls	Other	General Funds	Federal Funds	State Funds	Bonds	Total ($Million)
California	4.75	-	0.56	19.73	30.00	4.83	36.56	3.54	3,477
Florida	8.72	22.82	1.25	12.82	9.88	0.41	25.20	18.85	1,532
Illinois	22.26	17.41	1.99	9.80	6.35	0.11	37.60	3.47	1,036
Michigan	3.20	-	0.04	10.77	28.83	5.51	46.66	10.87	1,214
Minnesota	14.38	-	-	7.86	37.50	0.26	31.53	8.44	1,287
New York	14.92	0.02	0.19	3.69	55.49	0.63	7.48	17.54	3,242
Ohio	8.23	-	-	9.37	6.31	0.77	72.66	2.62	1,081
Pennsylvania	23.05	-	0.00	10.93	40.22	3.39	20.66	1.72	1,100
Virginia	1.20	13.52	2.58	5.89	33.42	1.49	25.20	16.66	611
Texas	29.51	2.95	2.01	11.97	41.37	0.43	2.96	8.77	2,750
National	14.95	2.86	0.56	10.69	32.15	2.59	28.31	7.86	30,166

Source: *Highway Statistics, 1991* (based on table LGF-21)

As Tables 9-3 and 9-4 demonstrate, there is a substantial variation among the major states in their highway fund raising mechanisms. New York has the lowest level of user taxes, but the highest dependence on toll roads and bridges, which explains the willingness to issue bonds for raising capital. Florida is another state that uses borrowing as an important component of highway finance. General funds are of limited importance for state highways, while federal funds tend to vary according to eligibility under federal allocation rules and levels of state spending. States also vary with respect to their commitment to aiding in funding roads for local jurisdictions. New York and Texas provide little local aid, which means that there is a substantial local tax burden in addition to state fund raising, with Texas localities the most dependent upon property taxation. Most states rely on a combination of state aid, local general funds and property taxes, with a smattering of various funding sources tapped to make up for shortfalls. Bonds are also far more prevalent at the local level.

Motor Fuel Taxes

Motor fuel taxes are the dominant mechanism for fund raising at the state level. A major advantage of the fuel tax is that it is imposed in small increments, reducing adverse reactions by taxpayers, on a large volume of transactions, providing a fairly stable source of funding. Motor fuel taxes also have low administrative costs, accounting for less than 1.1 percent of total revenues in 1990. Given the low elasticity of demand for gasoline and diesel fuel, it requires substantial price increases before there is a decline in the volume purchased and thus tax revenues. While alternative fuels will not be a threat to motor fuel revenues in the decade of the 1990s (though this issue may need to be considered in the next century, especially in light of the requirements of the Clean Air Act of 1990 and their potential for accelerating commercialization of alternative fuels), the gradual addition of more efficient cars to the automotive fleet (and retirement of gas guzzlers) should keep fuel sales relatively flat, especially with the slowdown in driving growth which is inevitable due to demographics and vehicle saturation.

Twelve states allow local jurisdictions to impose a local option fuel tax, including California, Florida, Illinois, New York and Virginia. In most cases these taxes range between 1 to 4 cents per gallon.[190] The total raised at the local level through fuel taxes was $280 million in 1985, about 2 percent of the total state fuel tax revenue.[191] Most states are reluctant to permit counties and cities to levy fuel taxes, even though a substantial fraction of state motor tax funds are shared with local governments or expended on roads that carry local traffic.

Motor Vehicle Registration Fees

License and registration fees are the second major source of state highway revenue, and since licensing is necessary for police and regulatory purposes, the additional cost of setting the fee at a revenue producing level is almost zero. However, overall collection fees are substantial, amounting to almost $2.2 billion, 13 percent of the gross receipts in 1990. Motor vehicle fees were more likely to be diverted to other uses than fuel taxes. While Texas and California are the only states that divert substantial amounts of fuel tax revenues, $4 billion in motor vehicle fees were diverted to state and local governments in 1990, leaving $10.2 billion for state highways, compared to the almost $20 billion raised through fuel taxes at the state level. About $4 billion of these fees were truck and trailer registration fees. However, fees in three states, Arizona, California and Washington, are personal property taxes on motor vehicles, and not true user fees. Motor vehicle fees are also used by local jurisdictions. In 1985 motor vehicle fees imposed at the local level generated $220 million in revenue.[192]

While registration and license fees for automobiles can be seen as "entry" fees for using the road system, these fees become more problematic with heavy vehicles, since they raise equity questions. Attempts to compensate for the cost responsibility of heavy trucks through

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[190] Joint Center for Urban Mobility, *Financing Urban Transportation Improvements, Report 3: A Guide to Alternative Financing Mechanisms for Urban Highways*, FHWA/PL/84/001, Washington DC: 1984.

[191] Kane, Anthony & Thomas Cooper, "A Preliminary Evaluation of Potential Sources of Revenue for Highway Finance," *Transportation Research Record* N1124, TRB, National Research Council, Washington D.C., 1987, p. 66-75.

[192] Kane & Cooper, 1987.

high registration fees result in horizontal inequities, as the same fee is paid by a vehicle driving relatively few miles as by one which accumulates substantial mileage. In the case of light trucks which have relatively low total road damage costs, a schedule of registration fees is much cheaper to administer than more accurate systems of cost assignment, and the divergence from the efficient measure is too small to justify the additional expense. However, registration fees cannot substitute for a weight-distance tax, even with higher diesel taxes. In 1990, revenues collected from motor vehicle taxes nationwide amounted to $15,548 million. Table 9-5 shows motor vehicle tax revenues raised that same year in ten large states.

Table 9-5. Motor Vehicle Tax Revenues, Selected States 1990 ($Million)

State	Registration Fees Auto	Registration Fees Trucks & Trailers	Titles & Licenses	Special Title Tax	Other	Total
California	2,013	1,023	64	-	284	3,384
Florida	196	129	43	-	251	619
Illinois	296	205	31	-	101	633
Michigan	246	142	44	-	60	492
Minnesota	221	74	17	-	40	352
New York	241	76	79	-	162	558
Ohio	206	142	23	-	115	486
Pennsylvania	164	220	85	-	111	580
Virginia	85	63	28	157	81	414
Texas	399	315	91	1,031	86	1,922
National	6,054	4,080	1,152	1,932	2,847	16,065

Source: *Highway Statistics, 1990* (from table MV-2).

Note: Other includes motor vehicle registration fees for buses and motorcycles, fines and penalties, estimated service charges, carrier gross receipts taxes, mileage ton-mile and passenger-mile tax, special license fees and franchise taxes, certificate or permit fees, and miscellaneous receipts.

Tolls

Tolls were responsible for a fairly substantial chunk of state revenue in 1990, bringing states almost $2.6 billion and localities an additional $750 million. However, they have limited use as a source of general highway revenue since the funds must be first applied to debt retirement and then toll road maintenance before it is proper to employ them elsewhere in the system. The advantage of toll roads is that by self-financing, they provide highway services without placing demands on limited highway funding. Since drivers on toll roads pay fuel taxes and registration fees, they can produce a net profit for the state even when operating at a small loss. While some observers have decried the seeming inequity of double payments by users, those who choose to drive on a toll road take in account their total cost of driving and are willing to pay the full price; therefore, they are receiving a benefit equal to or greater than their payment, or they can be considered irrational.

Parking Fees

Parking fees are an under-employed source of revenue for congested cities. While they are less efficient than congestion tolls or pollution taxes, parking fees and taxes can operate as substitutes when it is technologically or administratively impossible to apply a direct tax to the diseconomies produced by urban traffic. Parking fees can also help to correct a flaw in the tax system which encourages companies to provide parking for employees, thus acerbating congestion in crowded urban areas. Since a free parking space is not considered income, companies would prefer to provide parking to employees rather than a taxable transportation allowance, encouraging commuting.

For parking fees to work, care must be taken to prevent commuters from seeking out free parking on neighborhood streets or in residential time zones or metered areas intended for shoppers. New electronic parking meters, capable of charging variable rates and controlling several spaces at once, are making their way into the US market. The rates charged can favor short- vs. long-term parking, while the devices lower the cost of enforcement. At the same time that fees are increased in public parking places, taxing private parking, especially corporate parking, will raise additional revenues while compensating for the market distortion.[193] Washington State has passed legislation providing for a "Local Option Commercial Parking Tax," permitting local jurisdictions to impose a tax on a person engaged in a commercial parking business or on the privilege of parking a vehicle in a facility operated by a commercial parking business. A proposed tax for Montgomery County, Maryland would have imposed a tax of $60

[193] Higgins, Thomas, "Road-Pricing Attempts in the United States," *Transportation Research*, 20A(2), 1986, p. 145-150.

per parking space per year.[194]

Congestion Tolls

Congestion tolls, while the economic ideal for solving the problem of congestion, are impossible to implement for political, institutional and technological reasons at present. A number of compromises which would at least approximate congestion pricing to a third-best degree are available. Stretches of highly congested freeways could be closed during rush hour to non-permitted traffic, or a special lane opened, with enforcement using AVI technology. It might be possible in some cases to institute toll pricing given a stretch of road with limited access ramps. Another solution would be to use a general fee, such as a local option gasoline tax, to approximate a single peak congestion toll. If the revenues were to be dedicated to financing road improvements in the same jurisdiction, potential political opposition could be reduced. Houston is perhaps the prime candidate in Texas.

General Revenue - Nonuser Sources

Overall, general revenue for highways, excluding property taxes, remained around 20 percent of total highway revenue from 1965 to 1983, then gradually declined to 15 percent by the end of the decade. General fund appropriations of 1.5 billion dollars accounted for only four percent of state funding for highways nationwide (down from five percent in 1980), though they are a major source of funds in Alaska, with significant (>10% of state funding) general funds applied to highways in four other states (Georgia, Hawaii, Louisiana, and Utah). General funds are notoriously unstable since they depend on political whims and pressures. General fund appropriations are the primary source of general revenues, followed by investment income, selected sales taxes, and severance taxes and other funds. These other imposts accounted for an additional $1.4 billion, primarily in Arizona, Georgia, Iowa, Kansas, Missouri and Virginia.[195]

An ambiguous area of taxation involves sales taxes on goods and services used for transportation, usually the tax on motor vehicles, motor fuel and vehicle parts. Economic efficiency requires that tax rates on all goods should be set so as to lower consumption by the same proportion (Ramsey Rule), though in practice they are set at the same rate due to the complexity of meeting the efficiency conditions. Therefore a sales tax, on motor vehicles, parts and fuel, set at the same rate as on other goods, is a revenue collection device, not a user fee.

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[194] Etchart, G., Whitaker, B. and C. Ulbert, "Local Option Commercial Parking Tax Evaluation, Puget Sound Region, Washington State," *Transportation Research Board, 71st Annual Meeting*, Jan. 1992, Preprint Paper No. 920753.

[195] Kane and Cooper, 1987.

Only a tax above this level can be truly considered a user fee. This raises an interesting question in the case of a state like Texas, where the sales tax is not imposed on motor fuels, and therefore some of the user revenues are actually general revenues (the revenue that would be collected by extending the sales tax to motor fuel). Therefore earmarking sales taxes on these items to the highway department could be considered a transfer of general revenues to highways from an economic perspective.

General revenues from sales taxes, property taxes and occasionally income taxes are primarily sources of highway funds for local jurisdictions. Nationwide, general fund appropriations account for $5.8 of the $11 billion raised by municipalities and $2.7 of the $7 billion raised by townships and counties for roads in 1989. In addition, another $1.9 billion raised by cities and $1.5 raised by counties was derived from various general revenue sources, while over $2 billion in property taxes was earmarked for highways at each level of local government. One could attempt to make a case that earmarking a portion of property taxes to highways is actually a user fee since the property owner receives benefits from having roadway access to his or her property. However, the portion of highway costs which cannot be directly attributed to some party should be considered a general expense, since all members of society benefit from the public good provided by the existence of a road system. Police, fire protection, civil defense, and general social functioning require a well maintained road system, and all members of society benefit. Therefore using general funds, whether raised at the local, state or federal level, to maintain roads makes economic sense, although there may be legal reasons for maintaining the fiction of "user" fees.

The choice of the level of government to raise funds for general transportation expenditures is a political question insofar as the benefits provided are general public goods. However, the localization of revenue and benefits raises some questions concerning social justice, especially with regard to urban areas. Wealthy suburbanites are quite willing to finance the roads which take them in and out of the cities, but not the roads needed by the urban residents. In effect, commuters impose pollution, congestion, and parking rent costs on urban residents (increased demand for parking allows higher levels of land rents to be extracted from local residents). Therefore it may be economically efficient to assign part of revenues raised from exurban drivers to urban roads.

Earmarking of Funds

The rationale for earmarking funds for transportation has to do with political and budgetary considerations. Charging a proper level of user costs, including congestion fees and weight-distance taxes is important in order to guarantee efficient use of highway facilities, but it does not matter with regard to consumption efficiency how the roads are financed. From the production side, the important matter is the mechanism by which projects are chosen for funding, requiring the proper application of cost-benefit analysis. However, in the real world, decisions are rarely made with economic efficiency as the primary goal. Given the political temptation to scrimp on maintenance and to withhold funds for projects that have long lag times, dedication of highway funds prevents diversion and the related, inevitable, deleterious long-run impacts. Therefore, the importance of earmarking funds is that it assures a relatively stable and predictable stream of funds, allowing rational long-run planning of construction and maintenance schedules for the highway system. A variable and unstable source of revenues, even if on average the same funds were made available, would impose an additional cost in project delays and sub optimal scheduling of road work.

This is not to denigrate the importance of assigning users of the highway system their true costs, including all externalities. One reason for a gasoline tax is that it is the perfect mechanism for charging for noise and pollution externalities, at least until direct monitoring of emissions becomes feasible. Impact fees, special assessment districts, and other forms of assigning costs to development also are valuable both as a source of funds and as a means for applying market forces to developmental decisions. The choice of instrument should depend on the relative performance (whether the constraints are political, legal or technical) of the chosen mechanism in assigning the additional cost imposed on the local jurisdiction to the development in question. The advantage of an impact fee, if properly calculated, is that it provides a direct signal concerning the relative costs of building in different areas. While the other mechanisms for charging developers the external costs of their projects are cruder they all follow a similar principle; developers will not vote for an assessment district or agree to finance improvements unless they are economical. Conversely, if a developer threatens to move elsewhere when a reasonable request for compensation is made, the local government should refrain from compromise, since if the project was worth encouraging, then it should be able to cover the costs imposed upon the community.

Whether funds are directly earmarked to transportation or the legislature guarantees a stable source of income is irrelevant. Once the efficient investments in construction and maintenance have been identified, a stable source of funding is important to realize the social gains from prompt and efficient investment in the transportation infrastructure. This could be realized through earmarking of stable, adequate funding sources or by a direct, long-term commitment of funds. The choice of highway revenue instruments should be dictated by considerations of economic efficiency; proper assignment of full user costs will be socially optimal whether these are used specifically for highways or transferred to the general fund.

Bonds

Many states use bonds for highway improvements, including Florida ($336.9 million, FY91), Illinois ($100 million), New York ($554 million), Ohio ($100 million). Total borrowed by states in fiscal year 1990 was $2.5 billion, in fiscal year 1991, $2.8 billion.[196] The three types of bonds that have been used to finance highways are General Obligation Bonds, guaranteed by the full faith and credit of the government issuing the bonds; Limited Obligation

[196] TRIP, *1991 State Highway Funding Methods*, Washington DC: Road Information Program, May 1991.

Bonds which are secured by a pledge of a specific tax or revenue of a specific fund; and Revenue Bonds, obligations issued in support of specific projects, secured only by pledged earnings of the facility. The use of debt varies between both states, and states and local jurisdictions. Municipalities and counties also place heavy reliance upon bond issues, especially in Texas. While the state is restricted from using bonds to finance highway investment, except for toll roads, Texas local jurisdictions as a whole borrowed more money than local government in any other state during the 1980s.[197] As can be seen in Table 9-6, Texas local jurisdictions lead ten large states in accumulation of highway associated debt in 1989.

Federal Government Revenues for Highways and Transit

The Federal Highway Trust Fund has been a crucial source of funding for state highway programs, accounting for more than a quarter of all state funds available for highways. Sources of the fund are split between a gasoline tax and a group of taxes which primarily fall on heavy trucks. The primary source of funding for the Trust Fund is the 14.1¢/gallon gasoline tax, accounting for 60% of the $12.5 billion in total receipts (dedicated to highways) in 1990. The 20.1 ¢/gallon diesel tax was responsible for raising $2.9 billion. Taxes on truck and trailer sales (12 percent excise tax) accounted for $1.1 billion, the heavy vehicle use tax (by weight of vehicle) another $600 million, and an additional quarter of a billion dollars was raised from the tire tax (imposed according to tire weight). 1.5 ¢/gallon of the motor fuel tax is committed to funding mass transit, along with $580 million of the $1.54 billion in interest earned on investments by the fund.

In general, the ratio of apportionments to payments nationwide over the history of the fund has been around 1.15, but there is wide variation between the states. The states with the highest ratio of apportionments to payments tend to be either small eastern states (where Interstate funding has a large proportional impact) or sparsely populated western states. The system is designed to guarantee each state an amount sufficient to ensure that its percentage of total apportionments shall not be less than 85 percent of the estimated tax contributions to the trust fund.

There were a number of apportionment formulas for the Federal Aid Highway Program in 1990. The Interstate System Fund and the Interstate Substitute Highway Projects assigned funds according to the relative federal share of cost to complete the system. The Interstate Resurfacing, Restoration, Rehabilitation and Reconstruction (4R) Fund assigned 55% to interstate system lane miles, and 45% to VMT on the interstate system. The Primary and Secondary System Funds used area, rural population, urban population, and route mileage. The Urban System and Urban Transportation Funds employed urban population. The Bridge Replacement and Rehabilitation Fund used the relative share of total cost of deficient bridges. The Interstate Funds employed a 90% Federal and 10% State funds; the 4R,Primary, Secondary,

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[197] Doyle, John and Daniel Falter, "Highway Bond Financing, 1962-1982: An Examination," *Transportation Research Record* N1009, TRB, National Research Council, Washington D.C.,1985 p. 27-34.

and Urban Funds applied a 75- 25% split for funding; and the Bridge Replacement fund a 80-20% split.[198] Table 9-7 shows the Federal Highway Trust Fund apportionment/payment ratio for the year 1990 and for years 1956 through 1990 for the ten largest states.

Table 9-6. Total Debt by Selected States: Municipal, County, and State Level in 1989 ($1000)

State	State Debt	County Debt	Municipal Debt	Total Debt
California	85,140	145,441	550,546	781,127
Florida	1,873,129	313,062	114,838	2,301,029
Illinois	1,750,555	36,763	173,920	1,961,238
Michigan	294,900	37,441	82,524	414,865
Minnesota	112,593	47,161	659,307	819,061
New York	1,732,098	380,475	2,296,033	4,408,606
Ohio	271,938	23,232	294,519	589,689
Pennsylvania	2,750,904	44,995	79,379	2,875,278
Virginia	605,182	180,410	458,938	1,244,530
Texas	567,225	1,992,586	2,597,203	5,157,014
National	28,066,297	5,621,423	11,608,430	45,296,150

Source: *Highway Statistics, 1990* (from tables SB-2, LF-2, and UB-2).

County and Rural Road Financing

Rural areas face several major issues in financing roads and bridges. Changes in agricultural methods involving heavier farm equipment have increased demands on the local transportation network. The increasing scatter of tracts of land operated by one farmer increases travel distances and size of farm equipment on the roads. Large tandem-axle and semitrailer trucks, farm tractor-wagon combinations, and harvesting combines now travel from homesteads to fields, and are also used by farm supply and marketing firms for pickups and deliveries. Consolidated school districts use larger school buses to transport fewer children longer distances to schools.[199] Population declines force infrastructure costs to be paid by a smaller number of

[198] FHWA, *Highway Statistics, 1990* and Texas Department of Transportation, Division of Finance, *Texas Transportation Finance Facts*, 1990.

[199] Hamlett, C., G.R. Pautsch, S.B. Miller, & C.P. Baumel, "The Economics of Reducing the Size of the Local Rural Road System," *Transportation Research Record* N1116, TRB, National Research Council, Washington D.C., 1987, p. 74-81.

to schools.[199] Population declines force infrastructure costs to be paid by a smaller number of residents, resulting in increasing costs per resident, while the relatively poor performance of the farm economy in the early 1980s meant that property taxes increased relative to farmers' ability to pay. Federal general revenue sharing was eliminated beginning in 1987, while other local revenues, such as sales taxes, could not make up the shortfall, so local officials found alternative revenues such as user charges or local imposts. Closing roads or bridges is not politically popular, and as a result, local officials are tempted to spread financial resources over too many miles, given current traffic needs.[200]

Table 9-7. Federal Highway Trust Fund Apportionments/Payments Ratio 1956-1990

State	FY 1990 Payments ($1000)	Percent of Total	Ratio 1990	Ratio 1956-90
California	1,360,324	10.91	1.10	0.90
Florida	611,826	4.91	0.60	0.92
Illinois	513,839	4.12	1.02	1.13
Michigan	403,760	3.24	0.80	0.90
Minnesota	208,872	1.68	0.94	1.32
New York	562,188	4.51	1.34	1.21
Ohio	533,373	4.28	0.95	0.92
Pennsylvania	539,602	4.33	1.00	1.13
Virginia	331,555	2.66	0.90	1.27
Texas	915,875	7.34	0.94	0.86
National	12,472,077	100.00	1.14	1.14

Source: *Highway Statistics, 1990* (from table FE-221).

Nationwide, county roads and bridges are financed with a variety of revenue instruments:

[199] Hamlett, C., G.R. Pautsch, S.B. Miller, & C.P. Baumel, "The Economics of Reducing the Size of the Local Rural Road System," *Transportation Research Record* N1116, TRB, National Research Council, Washington D.C., 1987, p. 74-81.

[200] Walzer, Norman & Ruth McWilliams, "Financing Low-Volume Roads and Bridges: Results From a National Survey," *Transportation Research Record* N1291, TRB, National Research Council, Washington D.C., 1991, p. 3-13.

real estate property taxes, state intergovernmental assistance, often involving a sharing of state taxes on motor fuels, and federal intergovernmental assistance through the federal aid secondary highway program, and community development block grants. Per-mile county government receipts increased 7.4 percent in constant dollars between 1977 and 1987, from an average of $2,419 per mile to $2,598 per mile in 1987. Property taxes gradually declined in importance as a source of revenue in counties and townships for roads and bridges, falling from 20.3% to 17% of funds over the last decade. Reliance on combined federal and state intergovernmental assistance declined with the difference made up by a heavier dependence on user fees and imposts, as well as bonds.[201] As can been seen in Table 9-8, Texas counties receive little funding from state or federal sources, and are heavily dependent on property taxes and bond financing. It is noteworthy that the Texas legislature automatically appropriates a portion of its revenue for local "farm-to-market" rural roads. Only Texas has a mandatory funding appropriation for local rural roads, called "farm-to-market" and "ranch-to-market" roads. This category received the smallest allocation of funds.[202]

Table 9-8. Funding Sources for Counties and Townships: Major States 1989 (%)

State	Property Taxes	User Fees	Tolls	Other	General Funds	Federal Funds	State Funds	Bonds	Total (Mil. $)
California	2.0	0.0	3.1	28.2	13.0	7.7	31.8	12.5	1,020
Florida	9.5	19.8	0.1	10.4	29.0	0.2	20.1	8.6	1,283
Illinois	34.8	12.3	0.0	7.1	4.3	0.0	33.8	7.5	571
Michigan	2.9	0.0	0.1	11.1	24.2	0.2	60.7	0.8	591
Minnesota	35.9	0.0	0.0	3.9	14.4	0.2	44.8	0.8	487
New York	16.8	0.0	0.3	1.2	58.7	2.0	14.6	6.3	998
Ohio	6.6	0.0	0.0	5.9	3.1	1.4	80.7	2.0	533
Pennsylvan	11.7	0.0	0.0	10.8	35.1	5.1	33.2	4.2	445
Virginia	0.1	17.5	0.0	15.0	26.3	0.0	9.3	31.7	274
Texas	48.6	7.1	4.1	15.4	5.2	0.8	9.7	8.9	817
National	16.8	4.3	0.8	12.0	21.3	3.3	3.5	5.7	12,653

Source: *Highway Statistics, 1990* (based on table LF-1).

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[201] Walzer, 1991

[202] ITE Technical Council Committee 6F-39, "State Allocation and Prioritization Practices for Local Rural Road Improvements," ITE Journal 61, August 1991, p. 23-28.

Although reducing road mileage makes sense conceptually, politically, this policy is difficult to implement because adjoining landowners lose access to roads but gain little property tax savings. As a compromise to closing roads, some efforts have been mounted to stipulate that certain low-volume mileage will receive limited maintenance.[203] Residents on the roads argue that abandoning these roads or converting them to private drives will force farmers and rural residents to travel longer distances, and the additional travel and maintenance costs on these longer roads will exceed the cost savings. If the bridge maintenance and reconstruction costs are relatively low, the additional travel costs incurred from rerouting traffic tends to be greater than abandonment savings. However, there are high potential cost savings from abandonment of roads with no property accesses in areas with a small rural population and a core network of paved roads.[204]

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[203] Walzer, 1991.

[204] Hamlett, 1987.

CHAPTER X. TEXAS TAXATION ISSUES

Texas Highway Financing

In the 1970s the Texas Department of Highways found that financial resources, both state and federal aid, were lower than had been originally forecast. Although state revenues were growing at 6 to 7 percent per year, highway cost inflation accelerated during the 1970s, rising at 19 percent per annum from 1971-75. In addition, increases in motor fuel costs and energy policies led to a decreased growth rate for user revenues. The Highway department had committed itself to a large backlog of projects and there was growing concern that most of these would never be completed. In 1977, in response to a surplus in general funds together with a governor committed to "no new taxes," the state legislature provided funding from the state's general fund surplus and created the Highway Cost Index (HCI) Committee to attempt to forecast the increase in highway construction and maintenance costs. The object was to maintain a guaranteed level of funding relative to the cost of construction by using general fund revenues to supplement the regular highway user funds. The HCI worked quite well in providing additional revenues for highways for several years, but increasing demands on general fund revenues led to the need for alternative funding. The legislature discontinued the use of the HCI in 1984, replacing general revenue transfers with a 5 cent increase in the gasoline tax and with increases in motor registration fees.[205]

As can be seen from Table 10-1, these revenue enhancement steps reversed a decline in funding in real terms (excluding bonds, since these are merely a demand on future revenue). In 1987 the gasoline and diesel fuel tax was raised to 15¢/gallon, and to 20¢/gallon in September 1991. The Motor Vehicle Sales and Use Tax was increased to 5% in 1984 and to 6% in 1987. Despite these changes, the lingering regional recession has kept real revenues from growing since 1986.

Texas counties managed to substantially increase the resources devoted to roads during the early 1980s in response to rapid growth, but revenues declined during the recession period. One lingering problem is the rapid increase in debt accumulated during the mid-1980s in expectation of future growth. Payment of this debt will impose a serious drain on county finances in the 1990s. Municipalities are in a similar position, as rapid growth combined with increased urbanization forced increased reliance on debt, despite doubling the funds raised for urban roads. Tables 10-2 and 10-3 show county and municipal highway revenue sources in the last decade.

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[205] Euritt, M., K. Cervenka, C.M. Walton, L. Boske, and W. Grubb, "Texas Highway Finance: The Highway Cost Index," *Transportation Research Record* N1009, TRB, National Research Council, Washington D.C., 1985, p. 24-26.

Table 10-1. Texas State Highway Revenue Sources ($Million)

	Fuel Taxes	Vehicle Taxes	Other	Tolls	Federal Funds	Bonds	Total*	Total* (1990$)
1981	410.6	752.7	84.3	7.9	533.9	0.0	1,802.1	2,578.7
1982	368.0	544.4	97.2	11.4	444.2	153.8	1,490.1	2,007.5
1983	367.3	628.6	81.5	16.9	462.2	0.0	1,587.1	2,054.9
1984	340.3	729.6	89.9	18.1	553.6	0.0	1,738.4	2,156.8
1985	728.1	927.0	86.9	18.3	649.7	228.8	2,446.6	2,926.1
1986	744.6	841.2	256.9	19.1	920.8	0.0	2,845.2	3,315.0
1987	1,042.4	694.5	85.3	26.2	854.5	0.0	2,762.7	3,119.1
1988	898.4	576.5	80.5	31.9	910.7	0.0	2,559.4	2,781.1
1989	1,013.0	645.9	135.0	36.1	945.2	225.7	2,814.0	2,930.8
1990	1,045.6	706.7	100.2	40.4	1,120.0	125.9	3,055.5	3,055.5

*Not including bonds
Source: *Highway Statistics, 1981-1990* (from table SF-1).

Table 10-2. County Highway Revenue Sources in Texas ($Million)

Year Total*	User Fees	Tolls	Other	Property Taxes	Local Funds	State Funds	Federal Funds		Bonds	Total* (1990$)
1980	0.0	2.4	39.6	197.2	4.3	43.6	20.5	54.1	307.6	484.4
1981	50.6	3.2	0.5	259.3	7.6	48.8	18.4	70.2	380.4	544.3
1982	69.1	3.2	69.5	279.7	10.4	64.1	18.6	113.2	445.7	600.5
1983	0.0	2.7	63.4	232.7	19.4	72.1	19.4	86.3	408.0	528.2
1984	0.0	2.8	82.5	336.1	13.3	74.7	20.0	314.6	529.8	657.3
1985	0.0	3.1	143.9	404.5	73.1	78.4	18.2	989.3	721.2	862.5
1986	55.8	3.3	268.9	410.8	80.9	79.4	13.1	142.3	912.1	1,062.7
1987	52.7	4.5	91.1	343.2	58.3	79.9	5.9	486.3	636.6	718.7
1988	60.2	17.5	108.6	343.4	81.5	75.5	3.0	81.4	689.7	749.4
1989	58.3	33.7	125.8	397.4	42.9	79.7	6.6	73.0	643.7	670.4

*Not including bonds
Source: *Highway Statistics, 1981-1990* (from table LF-1).

Note: The Gross National Product implicit price deflator is used to estimate total revenues in constant 1990 dollars.

Table 10-3. Municipal Highway Revenue Sources in Texas ($Million)

Year Total* (1990$)	User	Tolls Fees	Other	Property	Local Taxes	State	Federal Funds	Funds	Bonds	Total* Funds
1980	0.0	7.2	97.1	131.5	355.5	0.7	69.1	139.2	631.2	993.9
1981	0.0	9.1	132.2	188.3	226.1	0.7	94.9	539.4	651.4	932.1
1982	0.0	10.5	143.4	176.7	503.4	0.9	85.3	143.0	950.5	1,280.6
1983	0.1	7.9	129.4	203.9	804.2	2.9	61.6	2.5	1,210.3	1,567.0
1984	0.0	7.9	141.8	242.4	584.6	3.1	64.0	224.9	1,243.9	1,543.3
1985	0.0	9.2	157.7	259.2	541.3	4.1	62.0	265.1	1,233.5	1,475.2
1986	0.0	10.7	189.0	287.5	573.9	0.0	62.4	1,088.2	1,125.0	1,310.8
1987	0.0	11.2	206.6	317.2	601.4	1.0	36.8	419.4	1,174.2	1,325.7
1988	0.0	13.0	193.7	342.0	658.3	8.5	21.8	299.7	1,240.5	1,348.0
1989	0.0	14.9	217.0	424.6	677.0	49.8	19.5	193.1	1,409.3	1,467.8

*Not including bonds
Source: *Highway Statistics, 1981-1990* (from table UF-1).

Motor Fuel Taxation

Currently the gasoline tax is 20¢/gallon, except 19¢/gallon for qualified transit companies, effective as of October 1991. The gasoline tax is paid by the distributor, with 2% allocated to the distributor for expenses. Gasoline used for purposes other than powering a highway vehicle is entitled to a refund. The tax is collected by the State Comptroller of Public Accounts. 1% of the gross tax is allocated to the Comptroller's Operating Fund (refunds are paid out of the net receipts). Of the remaining funds, 25% is allocated to the Permanent School Fund, and 50% to the Highway Fund. The first $7,300,000 of the remaining 25% is credited to the County and Road District Highway Fund, after which this fraction is allocated to the Highway Fund. The diesel tax is handled in a similar fashion, except transit companies pay 1/2 cent less, and the entire 75% is allocated to the Highway Fund. There is also a similar tax on liquefied petroleum gas (LPG) used for transportation. This LPG tax has been used as a precedent for CNG taxation as described previously. The Motor Fuel Lubricants Sales tax is a 6% tax on the retail price of motor oil and is allocated to the Highway Fund.[206] Table 10-4 shows how motor fuel tax revenues collected in 1990, 1991, and 1992 were allocated among the

[206] Texas Comptroller of Public Accounts, *Texas Taxes*, Spring 1989 and *FACTS Manual of Accounts, Volume II*, 1992.

the Comptroller Operating Fund, the Permanent School Fund, the County and Road District Highway Fund, and the Highway Fund.

Table 10-4. Motor Fuels Taxes (1000$)

Revenue Code	FY1990	FY1991	FY1992
3007 Gasoline	1,282,195.7	1,271,421.5	1,647,796.0
3008 Diesel Fuel Tax	229,978.7	235,859.0	303,118.0
3009 Liquefied Gas Tax	3,277.7	2,004.1	2,539.0
3010 Motor Fuel Lubricants Sales Tax	28,941.0	32,106.9	18,909.0
Total	**1,546,552.2**	**1,541,391.5**	**1,972,362.0**
Comptroller (1%)	15,154.5	15,387.6	19,534.5
Permanent School Fund	375,614.2	373,474.3	483,479.6
County and Road District Fund	7,300.0	7,300.0	7,300.0
Highway Fund Revenues	**1,148,483.5**	**1,145,229.6**	**1,462,047.9**

Source: 1990, 1991 figures are from *Texas: 1991 Annual Cash Report, Volume II*, 1992 figures communicated from the Comptroller's Office. Refund data was not available for 1990 and 1992, therefore comptroller's share is underestimated and highway fund revenues overestimated by around $200,000 in these years.

Motor Vehicle Sales and Use Tax--Motor Carriers

This is a tax on interstate motor vehicles, trailers, and semi-trailers operated by motor carriers which are residents of the state or doing business in the state. The use tax is calculated based on the carrier's total miles operated in Texas by interstate truck-tractors and commercial motor vehicles. The tax is equal to 6 1/4% of the purchase price of the vehicle prorated by the proportion of miles traveled in Texas to total miles traveled. Sales and use tax can be deducted from this amount. Obviously, vehicles purchased and used only in Texas pay the full amount. The revenues are collected by the Comptroller and deposited to the General Revenue Fund, with 25% to the Foundation School Fund and 75% to the General Fund.

Vehicle Sales and Use Tax

The vehicle sales tax is a tax of 6 1/4% on the retail sale price of each vehicle sold in this state or purchased elsewhere and used in Texas, less the value of a trade-in vehicle. There are also various small fees for vehicles brought into state after being registered in another state, vehicles exchanged for one another, vehicles transferred as gifts, and metal dealer plates. The tax is collected by the County Tax Assessor-Collector for the State Comptroller and deposited to the General Revenue Fund. 5% is retained by the Tax Assessor, of the remainder, 25% is allocated to the Foundation School Fund, and 75% to the General Revenue Fund. The Motor Vehicle Rental Tax is a tax imposed on the rentals of motor vehicles, and it is split 25% to the School Fund and 75% to General Revenue.[207] Table 10-5 shows how revenues collected from the different motor vehicle taxes in 1990, 1991, and 1992, were allocated to the School Foundation Fund, and the General Revenue Fund.

Table 10-5. Motor Vehicles Taxes (1000$)

Revenue Code	FY 1990	FY 1991	FY 1992
3003 Motor Vehicle Sales and Use Tax -Motor Carriers	11,444.2	15,376.3	11,464.0
3004 Motor Vehicles Sales and Use Tax	1,029,025.9	1,003,534.7	1,120,939.0
3005 Motor Vehicle Rental Tax	48,364.5	51,084.4	82,934.0
Total	**1,088,834.6**	**1,069,995.4**	**1,215,337.0**
School Foundation Fund	272,208.7	267,488.9	303,834.3
General Revenue Fund	816,626.0	802,466.6	901,502.8

Source: 1990, 1991 figures are from *Texas: 1991 Annual Cash Report, Volume II*, 1992 figures communicated from the Comptroller's Office.

Motor Vehicle Registration Fees

Motor Vehicle Certificates (Certificate of Title) are required for proof of ownership, and the fee is $13, with $5 retained by the county in which it was collected, and $8 remitted to the Texas Department of Transportation. Of the $8, $3 is allocated to the State Highway Fund and $5 to the General Revenue Fund.

[207] *Texas Taxes*, 1989 and *FACTS Manual of Accounts, Volume II*, 1992.

Motor Vehicle Registration Fees, required annually, depend on the age and weight of the vehicle. Vehicles over 6 years pay $40.50, between 3-6 years $50.50, and less than 3 years $58.50. A vehicle over 6,000 lbs. is charged $25 plus $.60 per hundred pounds. Truck tractor and semi-trailer are charged $40 plus a fee per hundred pounds as follows:

18,000-36,000	$.60 per 100 lbs.
36,001-42,000	$.75 per 100 lbs.
42,001-62,000	$.90 per 100 lbs.
62,001+	$1.00 per 100 lbs.

Tractors and trailers are also charged a separate fee if registered separately. There are numerous additional fees and exemptions, too numerous to be listed here. 100% of net collections are allocated to local county road and bridge funds until it reaches $50,000 plus $350 for each mile of county road, then 50% of the collections to the local account until they reach $500,000, and the excess to the Texas Department of Transportation. Personalized License Plates fees, amounting to $2,377,000 in FY1992, are allocated mostly to General Revenue, with 3.125% to the Highway Fund. There are also a number of Special Vehicle Registration Fees, including cotton related equipment, excess weight, hay transports, and oversize and overweight vehicles. This revenue is allocated to the Highway Fund.[208] Table 10-6 shows state motor vehicle registration fees net of fees retained by the counties for the years 1990, 1991, and 1992.

Table 10-6. Net State Motor Vehicle Registration Fees (1000$)

Revenue Code	FY1990	FY1991	FY1992
3014 Motor Vehicle Registration Fees	634,735.9	644,723.6	578,738.0
3018 Special Vehicle Registrations	9,285.6	12,336.4	8,003.0
Total	**644,021.5**	**657,060.0**	**586,741.0**

(According to TxDOT, gross collections in 1991 were $856,701,827. $74,396,506 went to the County Road & Bridge Fund, and $93,598,897 to the Optimal Road & Bridge Fee)
Source: 1990, 1991 figures are from *Texas: 1991 Annual Cash Report, Volume II*, 1992 figures communicated from the Comptroller's Office.

[208] *FACTS Manual of Accounts, Volume II*

Highway Fund Revenues

The two basic sources of state highway funds are Motor Vehicle Registration Fees and Motor Fuel Taxes. With the increase in the motor fuels tax the diversion of funds from highways has reached almost a half billion dollars a year, and if the Motor Vehicles Sales and Use Tax was also assigned to highways, about 1.7 billion additional dollars would be available for Texas Highways. On the other hand, if the Vehicle Sales and Use Tax and a percentage of the motor fuels tax is considered part of the state sales tax, and therefore not user fees, then the current allocation of funds approximates the revenue accruing from true user fees. If one includes motor vehicle externalities in the fund which should be assigned to highways, then there are additional uncollected fees that could be available to highways. Given the constitutional and legislative restrictions on the assignment of revenues in Texas, it is probably impossible to have a consistent allocation of funds that reflects costs and/or benefits to highway users. Since the state is facing a large fiscal deficit, any proposal to shift general funds, even if generated through highway user fees, will face fierce resistance. Table 10-7 shows transportation revenues from different fund sources in 1990.

Table 10-7. Transportation Fund Sources

Transportation Fund 006		**FY1991**
3001	Federal Receipts Matched	981,530,109
3010	Motor Fuel Lubricants Sales Tax	32,107,000
3012	Motor Vehicle Certificates	21,451,588
3014	Motor Vehicle Registration Fees	642,488,648
3018	Special Vehicle Registrations	2,018,595
3700	Federal Receipts Matched--Other Programs	2,400,763
3767	Supplies/Equipment/Services--Federal/Other	55,376,634
3901	Fund 001 Allocations	1,105,310,247
	(Gasoline, Diesel Fuel, and Special Fuel)	
	Other	23,252,633
	Total	**2,865,936,217**

Source: *Texas: 1991 Annual Cash Report, Volume II.*

There have been several suggestions for raising additional highway funds in Texas. Some options are shown in Table 10-8.

Table 10-8. Options For Raising Additional Highway Funds

Motor-Fuel tax (additional 5 cents/gallon with 1/4 to School Fund)	$360 million
Motor-Vehicle Sales Tax (allocated to highways)	$1,215 million
Vehicle Registration Fee (doubling of existing fees)	$642 million
Equivalent General Fund Transfer of School Fund Motor Fuel Taxes	$480 million
Sales Tax on Tires, Auto Parts, and Accessories (allocated to highways)	$128 million
Motor-Vehicle Rental Fee (allocated to highways)	$48 million
Interstate Motor-Carrier Sales and Use Tax (allocated to highways)	$15 million

Private Roadway Funding

The combination of a decline in funds, due partially to the oil price rise of 1979-80, and rapid growth, especially in the five major metropolitan areas, led the Texas legislature to enact House Bill 125 and Senate Bill 33 in 1984 authorizing the creation of transportation corporations and road utility districts, respectively.[209] The private corporation bill allows private property owners to form nonprofit, tax-exempt corporations that can accept property and funding donations primarily to assemble right-of-way for highway transportation projects. The legislation also states that such corporations may assist in the planning and design of transportation facilities. Preliminary alignment studies have been done with donated funds. A new transportation corporation is formed when at least three qualified electors file a written application to the Texas Department of Transportation Commission. The Commission will then vote on a resolution approving the creation of each corporation. The corporation is governed by a board of at least three directors who are appointed by the commission, which recently adopted a policy statement that prohibits elected officials and persons with substantial financial interests from serving on the boards. Donating landowners, or their representatives, may serve as nonvoting advisory members only.[210]

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[209] Euritt, M. and C.M. Walton, "Alternative Roadway Financing Methods: National Examples and Recent Experiences in Texas," *Transportation Research Record* N1077, TRB, National Research Council, Washington D.C., 1986, p.13-17.

[210] Barker, W. and L. Cooper, "Private-Sector Roadway Funding in Texas," *Transportation Research Record* N1107, TRB, National Research Council, Washington D.C., 1987, p. 102-106.

The first transportation corporation, the Grand Parkway Association, was approved soon after the legislation was enacted. The Association was created to assist in the planning and development of additional hurricane and emergency evacuation routes from Galveston and Brazoria counties. Among the authorized activities were preparation of alignment studies, solicitation of contributions of land and cash for right-of-way facilities for the parkway, and preparation of environmental reports and engineering plans.[211] The Commission passed a minute order authorizing the Association to issue bonds in the amount of $2,000,000, and the bonds were issued in July of 1991 in the principal amount of $1,500,000. The Association entered into a joint development agreement with Fort Bend County to fund engineering plans and specifications.[212]

While a few corporations were moderately successful, like the FM-3083 Conroe-Woodland and the MoPAC South Corporations which completed their projects, most have become inactive or attempted dissolution. The collapse of the real estate bubble in Texas and the extended recession in the region has diminished both the need for and the willingness to finance additional highway projects by the private sector.

The second bill, the Road Utility District (RUD) Act, authorizes the creation of road utility districts for the purpose of financing, constructing, acquiring, and improving arterial or main feeder roads and related projects. RUDs may issue bonds to the value of 25 percent of the assessed value of real property within the district supported by property taxes or assessing fees. An ad valorem tax on property within the district requires approval by two-thirds majority of voters residing in the district, but bonds can be issued without voter approval if backed by assessment fees. All of the property owners within a proposed district must petition the Texas DOT for approval to create a RUD. The RUD acts as an official subdivision of the state. Its major advantage is that it reduces the burden on a private developer to pay the full costs of roadway improvements. Instead, tax-free bonds are sold and paid for through the special ad valorem tax to spread the costs both over time and among affected users. It is limited by its applicability to only major arterial and feeder roadways.[213] Currently two RUDs have been approved by the Commission, the Denton County Road District and Northgate Crossing in Harris County. They have both been inactive due to financial difficulties of major developers in the districts.[214] Table 10-9 lists and describes the major transportation corporations created in Texas from 1984 through 1990.

Under new state legislation, a Municipal Utility District (MUD), with the water commission's approval, can petition the Texas DOT Commission to acquire powers granted to road utility districts (RUDs). As with the RUDs, 100 percent of the district landowners must petition the commission for this designation. If the petition is granted by the commission, the

[211] Euritt, 1986.

[212] Texas Department of Transportation, *Texas Highways Financial Summary*, 1991.

[213] Euritt, 1986, and Barker, 1987.

[214] Texas Department of Transportation, *Texas Transportation Finance Facts, 1990.*

district calls for an election to determine whether the MUD should exercise road utility district powers. On voter approval, the district must follow the procedures required for RUDs described previously. The major advantage of a MUD obtaining these powers is that the district with its governing body and taxation powers already exists.

Table 10-9. Texas Transportation Corporations

Name	Urban Area	Date	Length
Grand Parkway Association	Houston-Harris County	Oct. 1984	155
MoKan Corridor Association	Austin-Travis County	Aug. 1985	31.5
Galveston-Alvin-Pearland Transportation Corporation	Galveston-Bravoria County	Nov. 1985	43
FM-3083 Conroe-Woodland	Montgomery County	NA	NA
Plateau Region Outer Parkway Corporation	Austin-Travis County	Feb. 1986	7
MoPAC South Transportation Corporation	Austin-Travis County	April 1986	8.2
San Marcos Parkway Corporation	San Marcos	May 1986	26
Fort Bend Parkway Association	Fort Bend County	July 1990	NA

Source: Barker, W. and L. Cooper, "Private-Sector Roadway Funding in Texas," *Transportation Research Record* N1107, TRB, National Research Council, Washington D.C., 1987, p. 102-106 and Texas Department of Transportation, *Texas Transportation Finance Facts, 1990.*

The revised County Road and Bridge Act allows special county road districts (CRDs) to be established to levy an additional tax for roadway improvements within a district. CRDs are authorized and governed by the elected County Commissioners Court of the county in which the district lies. This court has the authority to develop roadways within the county. The Commissioners Court can establish a CRD by adopting an order declaring the district established and defining the boundaries of the district. Levy of the special road tax is initiated through a petition to the court by 50 qualified electors from the district. The court then orders an election to determine whether the county shall levy the tax, which cannot exceed $0.15 per $100 assessed value of property. Bonds not to exceed 25 percent of the assessed value of district property may also be issued by the district. CRDs are more popular than RUDs because they do not require the 100 percent landowner approval or the establishment of a separate governing body and can be used for any type of roadway. At least 11 such districts are proposed or in existence in

Travis and Williamson counties near Austin, and at least 15 other counties have CRDs.[215]

One caution, is that the public can be saddled with the results of speculation gone awry. This can occur during speculative booms when road projects are financed by bonds to be paid from projected revenues derived from future growth in a road district. When growth fails to occur, there may be an insufficient tax base to service the bonds, and the prospect of sharing this liability discourages new development in the region. This is the downside of road districts, in that social responsibility can force government to become involved even when there is no legal obligation. The problem is asymmetric risk and information, and the lag time before the persons involved become aware that a problem exists. Developers usually operate with borrowed money, and accept the risk to their own equity since bankruptcy law limits their liability. They also have superior information concerning the risks of owning property in the road district relative to homeowners who buy in their subdivisions. If the project works, the developer makes a great deal of money; if projected growth fails to materialize the developer has limited liability, the homeowners apply political pressure to be rescued, and the taxpayer foots the bill.

It appears to be quite common for developers in major Texas cities to negotiate with city transportation or planning staff to help provide needed roadway improvements in the area of the new developments. This can include new roadway construction, roadway upgrades, traffic signalization, and intersection improvements. Texas has a policy that projects with considerable local (public or private) funding should be moved up on the state wide priority program, providing an additional incentive for private contributions. In 1991 the value of right of way donated was $29.4 million, along with $4 million of plans and $.5 million in landscape materials.

The San Antonio Westside Freeway is an example of a joint venture to construct frontage roads and ultimately an expressway. The project cost was $93 million, with 80 percent of revenues from the state, 5 percent local in origin, and 15 percent private donations. Several major developers and landowners, along with the City of San Antonio, dedicated 461 acres of right-of-way in a 10 mile corridor for a new freeway linking northwest San Antonio with the Westside area and downtown, and also provided one-half of the cost of required frontage roads. The estimated value of the right-of-way is $13.2 million, with $5.9 million contributed toward construction of the frontage roads. SDHPT has agreed to pay for the other half of the access roads ($6 million) and the cost of the main lanes and interchanges ($68.2 million), with the main lanes to be added when traffic warrants.[216]

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[215] Barker, 1987

[216] Meisner, L., W. Merrill, S. Connelly & T. Snyder, *Public and Private Partnerships For Financing Highway Improvements*, NCHRP Report 307, TRB, National Research Council, Washington D.C., June 1988.

Toll Roads and Bridges

There are thirteen toll bridges crossing the Rio Grande, four of which are privately owned and the rest operated by border cities. Two bridges are operated by the Texas Turnpike Authority, in East Houston and West Dallas, and one is operated by the Galveston County Road District. There is one road operated by the Texas Turnpike Authority, the Dallas North Tollway, and two roads operated by Harris County, the Hardy Street Toll Road and the Sam Houston Tollway. The Harris County Toll Road Authority is the most ambitious local operation in the state, amassing $1.1 billion in debt in building 48.5 miles of the proposed 54.7 miles of toll system.

Tax Structure and Equity Considerations in Texas

As was discussed in Chapter VII, a recent study by the Congressional Budget Office indicated that the gasoline tax was regressive, taking a lower percent of income as incomes increase. Other information on expenditures was presented that shows that gasoline takes a remarkably constant percent of total expenditures as incomes increase. This data led to the conclusion that gasoline taxes are very equitable with respect to total funds available for expenditure, and this is more important than expenditures as a percent of income would suggest.

Since there are efficiencies of scale in gasoline usage (that is, weight of the vehicle increases faster than gasoline mileage declines), gasoline consumption and thus tax revenue will increase at a slower rate than damage to roads. For example, double the weight of the vehicle and gasoline consumption per mile will less than double, but damage to roads per mile will increase by a factor of 8-16 given the same axle configuration (third power or fourth power rule). With regard to capacity and general costs, a gasoline tax is more likely to be equitable, as the size of vehicles will be positively correlated on average with gasoline consumption, and tax revenue will be directly correlated to vehicle miles. There is also a problem of horizontal equity due to varying gasoline efficiency among vehicles of the same weight and size; a 2,700 lb. sportscar could obtain half the gas mileage of an economy sedan of the same weight, and therefore pay twice the tax revenue despite causing the same damage and requiring the same road capacity.

A similar effect will be seen with diesel taxes as heavier truck tax revenue will increase far slower than the damage caused to roads. There is the additional problem that road damage depends on both weight and axle configuration, which further weakens the relationship between road damage and fuel consumption. Horizontal equity will be less of a problem than with automobiles since trucks are built primarily for hauling goods and have similar weight to consumption ratios in the same vehicle class.

The Motor Vehicle Registration fees, the other major source of income, also exhibit significant flaws in terms of equity considerations. The logic behind the fee is hard to ascertain, since the declining rate for older cars would seem to be an attempt to make the fee a progressive tax, but the fee declines at a slower rate than the value of automobiles, while there is no attempt to relate the fee to the blue book value of vehicles. The fee also ignores vehicle mileage, so it acts as an entry charge and not a user fee. The registration fee for trucks partially deals with equity considerations, as there is a sliding scale according to weight. However, there is no consideration of axle alignment, and the increase in fees with weight is far less than would be dictated by average damage due to weight classes; for example a 60,000 lb. truck would pay $580, and a 80,000 lb. truck, $840. Therefore the fee falls short in terms of both vertical and horizontal equity, as it fails to account for differences between vehicle classes or in usage of vehicles in the same vehicle class.

The 1985 Texas Highway Cost Allocation Study results shown in Table 10-10 indicated that automobiles and pick-ups were over-charged due to the dependence on fuel taxes, and the lack of a sufficiently weight graduated scale for registration fees. While there have been some changes in Texas taxes since the study, there is no reason to expect a significant shift in responsibilities and revenues, given that motor fuel taxes and registration fees are still the dominant source of state funding.

Table 10-10. 1985 Revenue-Cost Ratios

Vehicle-Class	% of Vehicles	Revenue per Vehicle	State and Federal	State Only
Passenger Cars	67.34	$128	3.08	3.55
Pickup Trucks	25.37	$154	3.01	3.41
Other 2 Axle Trucks	_	_	0.20	0.23
All Combinations	_	_	0.45	0.29
3S2 Trucks	0.86	$4,613	0.53	0.34

Note: State and Federal Ratio assumes costs are 35 % rehabilitation and maintenance and 65% construction, State only assumes a 40-60 cost ratio. Increasing the maintenance/construction cost ratio slightly lowers the revenue-cost ratio for heavy trucks.
Source: Villarreal, A., et al., *The Texas Highway Cost Allocation Study*, December 1987. Unpublished report.

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CHAPTER XI. SUMMARY AND CONCLUSIONS

While the end of the explosive growth which Texas, and particularly the major Texas cities, Dallas, Houston, Austin, San Antonio and El Paso, experienced during the 1970s and early 1980s has allowed some breathing room, it is becoming painfully obvious that highway funding in Texas is inadequate with respect to the demand for highway services. Given the resumption of growth in the 1990s, albeit at a slower pace than previous years, the high level of debt already encumbering local jurisdictions, and the restrictions on local revenue instruments, the necessary funds will have to come from the State. Considering the fiscal limitations that the legislature probably will operate under during the 1990s, this may seem like a recipe for disaster for Texas Highways, but it can also be seen as an opportunity for reforming the current system of highway financing.

The problem with Texas highway financing is, like most states, there are no explicit criteria for judging the relative efficacy of various tax instruments. Once the basic principles by which a highway system should be financed are established, a package of various taxes and fees can be devised that will meet this goal. The current system of highway taxation provides neither a stable source of income which permits long run planning, nor a consistent rationale that would make higher fees acceptable to the general public.

Three general principles could be used as a guide to determining an optimal package of highway revenue instruments; progressivity, horizontal equity and vertical equity. While highway funding should not be considered a mechanism of income redistribution, it is not unreasonable to attempt to develop a system of highway taxes and fees which would be income neutral, if not actually progressive. For example, if a gasoline tax is considered an important component of such a system, then automobile registration fees could be weighted according to vehicle value or at least to increase the differential between fees for new and used cars.

Horizontal equity requires treating vehicles in the same vehicle class equally, while vertical equity requires assigning revenues to classes of vehicles according to their cost responsibilities. The key here is to base fees on cost responsibilities of vehicles and to avoid exemptions, whether as an attempt to subsidize agricultural interests or independent truckers, provide benefits to deserving individuals, or shift the tax burden from rural to urban districts. If the legislature feels that some specific group is worthy of a subsidy or lesser tax burden, it should vote directly upon the issue and not impose complicated requirements upon the highway tax system. In the same way, excepting constitutional requirements, the allocation of funds should be made as simple as possible.

The following discussion briefly reviews the various options for highway finance with respect to the following criteria for evaluating alternative revenue sources:

1. Political or Public Acceptability
2. Revenue Potential and Stability
3. Equity
4. Economic Efficiency
5. Administrative Ease
6. Applicability

Motor Fuel Taxes

Gasoline taxes have a number of advantages; when earmarked for highways, they are politically acceptable, provide a fairly stable and sizable source of revenue, and are easy to administer with very low collection costs. One weakness is that with the increasing efficiency of the automotive fleet, rates will have to be periodically escalated to maintain constant real revenues. They are primarily a state and federal tax, though municipalities have applied local gasoline taxes. One advantage of municipal gasoline taxes is that by raising the cost of driving in urban areas, they act as a crude surrogate for congestion fees. A major disadvantage that has often been mentioned for fuel taxes is that they are considered to be regressive; however, information presented in this report shows that the percent of total expenditures spent on gasoline and oil tends to remain relatively constant for higher levels of income, suggesting that the idea of regressivity based on income level alone may be somewhat mistaken. This finding, plus the suggestion that other taxes and expenditure policies should be used to assure equity across incomes/expenditures, with efficiency being the primary goal in transportation, leads to the conclusion that motor fuel taxes rate better on equity grounds than is usually recognized. Another limitation for motor fuel taxes is that there are considerable differences among passenger vehicles in terms of fuel efficiency, leading to some fuel efficient vehicles paying considerably less for fuel taxes per mile than the inefficient vehicles. (Directly charging for roadway use through toll charges is somewhat superior to motor fuel taxes on this criteria.) The only direct way to correct the motor fuel tax for these differences would be to charge a different tax per gallon to different vehicle types, and this probably would be impractical.

Diesel taxes share the advantages and disadvantages of gasoline taxes though they primarily fall upon trucks and other heavy vehicles as diesel automobiles have fallen out of favor with the general public. Since vertical equity is a far more important issue with heavy trucks, diesel taxes are less acceptable than gasoline taxes. The equity question can be dealt with through a weight-distance tax or a highly graduated system of registration fees based on weight combined with a diesel tax.

Special fuels taxes, such as taxes on liquid petroleum gas or compressed natural gas, present no additional issues. While it may be state policy to promote the use of natural gas, vehicles powered by CNG will require the same road capacity and still cause the same damage to roads as other vehicles. Therefore, there is no reason to exempt them from the same levels of fees paid by other vehicles, based on average mile per unit of fuel consumed.

The one exception involves the decision to implement pollution taxes. Since air pollution is an externality associated with the operation of gasoline and diesel engines, and on average the amount of pollution is correlated with the amount of fuel consumed, it would be efficient to add a pollution surcharge which would reflect the environmental damage of burning these fuels. If alternative fuels caused less pollution, they would face a lower surcharge. To properly assign pollution taxes, one should account for emissions from different types of engines, possibly through a registration surcharge combined with some form of inspection program. The location of the pollution might be taken in account, as the marginal cost of additional emissions are higher in urban areas. Since a pollution surcharge should compensate all victims of pollution, the revenues should be assigned to general revenues, allowing return of highway user fees, which are currently diverted from the highway fund.

Motor Vehicle Registration Fees

Automobile registration fees tend to be regressive in nature, since they are the same irrespective of the value of the vehicle, and therefore proportionally greater for lower income car owners. Lowering fees on older cars, as is currently done, mitigates some of the regressive nature of the fee, but it tends to decline at a slower rate than the value of the car (and the probable income of the owner). One potential problem is if older cars produce more pollution per gallon of gas consumed, they should be charged a pollution fee to account for this additional production. An alternative would be a pollution fee based on the additional average expected emissions, which would still fall harder on older vehicles. This illustrates the difficulties of developing an integrated system of fees--often attempting to achieve one goal moves you further from approaching another objective.

Registration fees have substantial collection costs, about 13% of revenues, and are far more complex to administer. However, an increase in these fees with the same or similar structure of taxes probably would have a very small incremental tax, and this would be the most relevant criteria. Since registration, like licenses, is part of the information needed for policing highways and apprehending malefactors, a sizable fraction of the costs can be attributed to public safety purposes and not highway finance. They seem to be accepted as the entry fee to the highway system and provide a stable source of income. Vertical equity could be improved if fees were based on vehicle weight, though this is a minor issue with passenger vehicles. If common costs are allocated according to passenger car equivalents (PCE), and fees are set accordingly, then registration fees for automobiles could also be considered approximately efficient. One suggestion to lower collection costs and improve efficiency would be to eliminate the numerous exemptions and varying fee levels for different vehicles that currently exist.

Registration fees for trucks present a more complicated problem. If there are other mechanisms to account for ESAL miles, then a truck registration fee would be no different than that for automobiles, serving as an entry fee based on passenger car equivalents.

However, if some form of weight distance tax is not implemented, then truck registration fees should be designed to achieve vertical equity on an average basis (they are too crude to be used for fine tuning) by a substantial increase in the graduated fee using ESALs rather than pounds as the basis. Set a base fee according to the vehicle's PCE, and then charge per ESAL, using the average mileage of heavy trucks and the resulting damage costs. If the diesel tax exceeds the value needed to equalize vehicle fees with cars on a PCE basis, include pollution charges, then subtract the expected excess payment (again based on average mileage) from the registration fee schedule developed above to determine the final schedule. While this would require some calculation, it is not unduly complicated and would result in a schedule of registration fees which more closely reflects the average costs of each vehicle class.

Currently, registration fees in Texas for cars, pickups, and vans are relatively high compared to similar fees in other states, but registration fees for trucks are low compared to most other states. This suggests that registration fees for passenger vehicles probably should not be increased, but that for trucks, they should be. The fact that registration fees for trucks are low in Texas and are considerably lower than those suggested by most highway cost allocation studies supports increasing registration fees for trucks on the basis of vertical equity, and also to promote efficient use of intermodal transportation. The equity consideration may be somewhat offset through having a competitive trucking industry that has relatively low profits, indicating that truck tax increases probably are passed along to the general public anyway. This, together with the consideration that increased registration fees, without basing them more on weight (or damage) and mileage, tends to suggest that the basis for registration fees probably should be changed for trucks if there is to be a major increase in such fees. However, an argument can be made for increasing these fees periodically to adjust for inflation.

Other Motor Vehicle Fees

The Highway Fund currently receives the revenues from the Motor Fuel Lubricants Sales Tax and Motor Vehicle Certificates, accounting for $50 million annually. Given that Texas already taxes sales of motor vehicles, tires, auto parts and accessories, there is no real justification for additional taxes on these items since they will not improve equity or efficiency. There is also no justification from the benefit principle in assigning these funds specifically to highways (except for tires), since these taxes are part of the general taxation of goods in Texas. (If the sales tax were to be reduced or replaced by an income tax, this position would need to be reconsidered). Purchases of these items are not directly correlated in increased highway costs (except for tires and motor oil), and use of these items is covered by fuel and direct use taxes.

Weight-Distance Taxes

Weight distance taxes (WDT) are the ideal mechanism for assigning the true costs of travel to heavy vehicles. They are feasible and not too difficult to administer, as ten states currently receive a substantial amount of revenue through the application of some form of WDT. Texas currently has one of the lowest per mile rates of charges for heavy trucks, in effect, subsidizing trucks through higher fees on automobiles and under financing of highways. Given current technology WDTs can be implemented at a reasonable cost for both the state (total costs in Oregon are 7% of revenue) and trucking firms, and new technology promises to lower the cost over time. This would provide a substantial source of stable revenues (trucking mileage has a low variance); doubling the charges to heavy trucks would bring the state more than $200 million a year in additional revenue. An additional benefit is the closer monitoring of heavy trucks due to a WDT, which if combined with a much stiffer set of weight graduated penalties for overweight travel (reflecting the marginal damage cost and expectation of detection), could substantially lower damages to secondary roads in Texas. By allocating some of the savings from a more stringent truck weight enforcement program to the Texas Department of Public Safety, additional revenue could be made available to the state merely through increased collection of higher levels of fines, with or without a WDT.

Driver License Fees

Since vehicles cause road damage, not drivers, it makes more sense to fund highways from vehicle use taxes. Driver license fees can be seen as payments for police services, as these licenses are used to control access to legal operation of vehicles. Therefore these fees should be dedicated to public safety.

Tolls

Tolls are easy to apply (though costly under present technology) and toll roads are used by both local and state government. Tolls are valuable when applicable because they are direct charges for use of the road, and the driver's willingness to pay signifies both acceptability and reception of an equivalent or greater benefit. However, this assumes there are reasonable alternatives, and the driver is paying for reduced congestion or shorter travel distance. It is unlikely that tolls would be as politically acceptable if they were imposed on roads which were previously "free." In highly congested urban areas, tolls on new roads or new sections of roads are economic due to the large amount of traffic which would be willing to pay for reduced time or distance of travel. In most Texas cities, it is unlikely that toll roads would be economic unless they replaced free roads.

Congestion Fees

Congestion fees can be seen as "tolls" on formerly free roads when the loss of time due to congestion is sufficient to justify the expense of instituting a congestion toll system. Given the structure of the present highway system, it is difficult to see how a congestion toll system could be implemented in general without a high degree of government intrusion and monitoring. Newly emergent technology could allow voluntary congestion tolling under a hybrid system in which some roads would be open only to vehicles with electronic identification during peak periods. Since individuals would have the choice to join the system or use other roads, they would have less objections than if entire urban areas were included under the system or roads were tolled in all periods.

There are some questions concerning redistribution with congestion tolls, as those drivers with a higher time value would receive the most benefits, while some poorer workers, with little control over work hours, might actually experience income losses. One solution might be to use part of the funds to subsidize mass transit (focused on poorer areas), or permit other fees to be structured to increase the progressivity of the entire fee structure. The overall efficiency benefits suggest that it would be socially beneficial to invest some of the gains in assuring public support for a congestion fee scheme.

The second best substitute for congestion fees would be an urban motor fuel tax surcharge which could be set for the major urban areas with declining rates for surrounding communities, if necessary, to prevent evasion. This would act as a single period congestion toll, and by applying these revenues to the areas where they were collected, could finance additional capacity to relieve congestion. Since the political acceptability of such a surcharge would probably depend on the level of congestion in the region in question, there would be an automatic check on abuse of this privilege. Care would need to be taken to guarantee that the surcharge would only be used for additional capacity and not to replace other local road funds, possibly through requiring TxDOT to approve charges and expenditures.

Parking Charges

Parking charges are a third best solution for congestion in urban areas. They may be counterproductive unless measures are taken to prevent spillover from commercial to residential areas. Equitable application is difficult since it would require that private parking (company owned) also be charged the fee; otherwise it merely increases the value of private parking. One factor which would help is an IRS ruling that parking privileges be considered taxable income, which would reduce incentives to supply workers with free parking. Care must also be taken to ensure that parking fees do not increase the cost of shopping and visiting the CBD during off peak hours, since this could have detrimental effects on the economic viability of central city areas, resulting in intense opposition from city merchants. Given the limited income available through this instrument, it may be more trouble than it is worth, unless lowering urban VMT is necessary to meet the requirements of the Clean Air Act.

General Revenue - Nonuser Sources

General revenues other than property taxes should be considered the last resort for highway financing. There is intense competition for these funds, and unlike highway user fees, where there is a strong argument for application to roads, the diversion of general funds to highways will be strongly resisted by other groups fighting over the same pie. The one exception is the share of motor fuels taxes diverted to the School Fund, since these, it can be argued, are motorist user fees, general revenues should be transferred to compensate highways for the loss.

Property Taxes and Fees

Property taxes can be considered an acceptable source of funds for local roads because these roads are necessary for access to the property, and therefore contribute to the value of the property and any economic rents received by the owners. Given that local property owners are the most likely to vote and have the most political influence in local jurisdictions, there is limited potential for abuse of this revenue source.

A special situation exists in the case of new development which imposes incremental costs on the highway system. In this case, additional charges to pay for the marginal cost of adding additional capacity and thus serve the increased vehicle load seems both fair and politically acceptable. Special assessments, exactions or impact fees can be determined to assign these costs to developers who stand to profit from the increased value of the land due to addition of highway capacity, which allows improved access to this land. The advantage of impact fees is that they provide a method of imposing an approximately uniform charge on various developments, avoiding the charge of differential treatment. Negotiation is not recommended on the grounds that it leads to differential treatment, allows significant advantages to developers with extensive resources, and may raise the specter of corruption.

Private Sources

Private sources seem to be a viable way of financing additional highways, but it is difficult to assure that private contributions promote the overall public interest. No developer is going to provide government with land or money unless he or she expects to gain a sufficient return. This does not mean that the gift, whether it be a right-of-way, funding or other assistance, is necessarily to the disadvantage of the public. However, private interests do not necessarily coincide with the public interest. Many states require that private efforts be permitted only when they fit into existing county or state highway development plans. This, in effect, allows private interests to accelerate existing plans but not to dictate the shape of the public road system. By following this principle and guaranteeing that decision making on roads remain in the public domain and under public scrutiny, conflicts between public and private interest can be minimized.

The same principles apply to joint development or private ownership and operations. Since private roads are built with the expectation that they will connect to and utilize the public road system, they cannot claim to be independent of public control. Even when a private interest is willing on paper to take full responsibility, history teaches us that when there is a public interest at stake, government will be the insurer of last resort. When a road district or even a private toll road becomes insolvent, political pressure to aid people stranded by the private failure will eventually involve government. Therefore, it behooves the state to take an active role in monitoring and guiding all private highway actions. This is not to say that interventions by private actors should be discouraged--just that laissez-faire cannot apply to the sort of private activity which inevitably impinges on the public interest.

Debt

Using debt to finance the capital costs of highways is a rational economic mechanism of spreading the cost over the future beneficiaries of the investment. Assuming that the decision to invest is made prudently, taking in account the net benefits of the project and applying conservative estimates of future highway demand, debt can be a valuable addition to the highway finance tool kit. There are two problems with debt. One is the tendency by localities to incur debt to build roads for hypothetical development, leaving future generations with a crushing burden if this development fails to emerge; the second is to use debt as a means of avoiding or postponing difficult fiscal decisions. Debt should never be used to finance current expenses such as maintenance.

In Texas there seems to be a tendency for local jurisdictions to take on debt at very high levels, at least in comparison to other states. This may be due partially to the limited state funds available for local road building, as well as a product of the rapid growth of the 1970s and early 1980s, which both resulted in a backlog of road projects and unrealistic expectations that growth would continue indefinitely. One danger is that debt service and the maintenance requirements of an expanded local road system may come to tax the resources of some localities in coming years.

Criteria Summary

With reference to Chapter 4 and the analysis of various taxes in subsequent chapters, Tables 11-1 through 11-5 present a summary of the evaluation of the different revenue sources discussed previously. Criteria are broken down into two major groups, the first relating to basic conditions to be met by the tax and the second including practical considerations for application.

Basic evaluation criteria include:

- Equity: The idea of horizontal equity refers to assessing fees proportionately to cost responsibilities and benefits, while vertical equity studies how the impacts of a revenue source are distributed among income groups.

- Efficiency: Efficiency refers to the extent to which the tax affects the economy and meets the objective of maximizing social benefits with relation to costs.

- Revenue potential: This criterion involves the amount, the stability over time and the evasion potential of revenues raised by the tax.

Practical considerations include:

- Acceptability: Acceptability refers to the taxes public, political and legal support.

- Administrative feasibility: This criterion evaluates administrative costs (including collection, processing, enforcement and evasion costs) and compliance burden costs (including record keeping, preparation and submission costs.)

- Applicability: Applicability refers to the appropriateness of a revenue source in a defined context regardless of administrative costs.

Table 11-1. Summary of Evaluation Criteria for User Fees.

	CRITERIA					
	Basic Evaluation			Practical Considerations		
USER FEES	EQUITY	EFFICIENCY	REVENUE POTENTIAL	ACCEPTABILITY	ADMINISTRATIVE FEASIBILITY	APPLICABILITY
Motor Fuel Taxes	• Well met; cost responsibilities assessed to users. •For passenger vehicles, amount spent on fuel is relatively constant as percent of total expenditures at different income levels.	•Relatively efficient because users pay the tax. • In the long run higher transportation costs, as a result of higher taxes, may affect consumer goods prices, capital investments, labor employment and productivity but productivity gains probably more than offset the cost.	• The most important source of revenue. • Disadvantage: not sensitive to inflation under a static form. •Under a variable form revenues fluctuate with prices (but when prices fall revenues are lower) • Floors and ceilings prevent sharp fluctuations.	• Closely related to benefits received from highways and therefore well accepted.	• Easy to administer in general and low cost. • Under a variable form, more complex requiring periodic review and enforcement programs. • Administrative costs are high and legal feasibility expensive when applied at the local level.	• Limited at the local level. •The more the local motor fuel tax structure differs from the state tax, the higher administrative costs are. • Collection costs are lower when undertaken at the state level.
Vehicle Registration Fees	• Attempts to compensate for cost responsibilities of heavy trucks through higher fees raise equity issues: distance is not taken into account; vehicle registration fees do not replace weight distance taxes. • Less regressive and more effective when computed as a function of the vehicle's age and value.	•Do not promote efficiency as well as weight-distance or weight-damage taxes.	• Second major source of revenue • Taxes levied as a percentage of the estimated market value are sensitive to inflation.	•Generally accepted. • Because of its high public visibility, revisions may be subject to wide objections.	• Expensive: costs estimated at 13% of receipts.	• Either flat rate or graduated according to weight or horsepower. • Computed as a function of the vehicle's age and value in few states.

Table 11-1. Summary of Evaluation Criteria for User Fees. (Continued)

User Fees (Continued)	Equity	Efficiency	Revenue Potential	Acceptability	Administrative Feasibility	Applicability
Third Structure Taxes	•Can promote cost responsibilities that are proportional to the damage caused on highways by vehicles according to their weight, configuration and mileage traveled.	• Weight and distance travelled constitute an acceptable compromise for a more efficient tax given the difficulty of measuring all other variables that affect cost responsibilities (i.e., type of roads, climatic conditions...). • Could affect interstate commerce by diverting traffic to rail and/or by increasing shipping rates.	• Productive source subject to business economic cycles.	• Opposed by owner/operator truckers: trucks are already fairly taxed; the trucking industry has narrow profit margin already.	• Administrative costs evaluations as a percentage of revenues range from 2 to 11%. • Carriers already keep records on distance travelled and therefore compliance costs are low. • Under a uniform state administered form costs of auditing records and enforcing the tax are lower. • Evasion can be avoided with a "proof of payment" program.	• Because of legal and institutional issues uniformity is better.

Table 11-1. Summary of Evaluation Criteria for User Fees. (Continued)

USER FEES (CONTINUED)	EQUITY	EFFICIENCY	REVENUE POTENTIAL	ACCEPTABILITY	ADMINISTRATIVE FEASIBILITY	APPLICABILITY
Tolls	• Most precise form of "pay-as-you-go" financing. •Disadvantage: perceived as double taxation since users are already paying motor fuel taxes. • Negative impact on development in the areas near toll roads (less frequent access).	• Expedite construction completion . • Funds flow directly from the user to the provider and are available at the beginning of a project. • Must cover operating and maintenance costs plus debt expenses. • More efficient when function of time of the day and nature of the vehicle. • Capital costs during inflation are lower because of quicker implementation. • Disadvantage: externalities when vehicles stop to pay (ie., time delay, air quality fuel consumption) plus interest costs.	• Continuous source of revenue to cover maintenance and operating costs. • Depend on demand level, traffic mix and changes in travel behavior. • Demand is affected by the level of improvement on "free" highways. • Do not respond promptly to inflation because rate changes are complex from the political standpoint and increases reduce the number of users.	• Public support is necessary: a toll road must provide advantages as compared to a free facility to win acceptance.	• Collection costs are high (estimated at 18% of revenue). • Administered and operated by state authorities. • Do not have to comply with Federal regulations.	• Most useful in urban areas where demand level is high enough. • Insulated from political influence because usually governed by an independent board of directors. • Financed by general obligation bonds, revenue bonds, private financing or combinations of these.

Table 11-1. Summary of Evaluation Criteria for User Fees. (Continued)

USER FEES (CONTINUED)	EQUITY	EFFICIENCY	REVENUE POTENTIAL	ACCEPTABILITY	ADMINISTRATIVE FEASIBILITY	APPLICABILITY
Tire Excise Tax	• Good tax for increasing vertical equity between cars and trucks. • Equitable since associated to the most important cost responsibility factors, weight and mileage •Retread and new tires cause same damage; when the tax is applied only on new tires equity is reduced	• Varies with weight and mileage; well related to cost responsibility. • Little or no effect on interstate commerce: carriers prefer to buy new tires and avoid problems and delays.	• Function of the level of demand for tires. • High possibility of evasion when applied at the state level: tires can be purchased in non-taxing states.	•Generally acceptable. •Similar to general sales tax.	• Low costs	• Better when applied at the federal level.

Table 11-2. Summary of Evaluation Criteria for Non-User Fees.

	CRITERIA					
	Basic Evaluation			Practical Considerations		
NON USER FEES	EQUITY	EFFICIENCY	REVENUE POTENTIAL	ACCEPTABILITY	ADMINISTRATIVE FEASIBILITY	APPLICABILITY
Sales Tax	• Sales of vehicles and parts are fairly well related to transportation use.	• Does not discourage economic development. • Objections: may lead to public overspending because the taxes are hidden in the prices of the goods. • Might be regressive.	• High reven potential. •Potential source of transportation revenue if sales on transportation items are dedicated.	• The most acceptable form of general taxation. • Accepted by economists and businessmen: does not fall on investment.	• Relatively easy to administer.	• Applied at state, local, and federal levels. • Legal impediments at the state level involving imported goods and mail sales.
Property Taxes and Fees	• Rates are not uniform; fairness problem.	• Burden distributed roughly in proportion to income. • Because of exclusions, wealth is not really the base of the tax.	• Important source at the local level. • Predictable revenues because the rate is set after the value of the base is known.	• Limited to voters. • High to state officials because the alternative would be an increase in state taxes and aids.	• Hard to evade. • Slow structure changes.	• Mainstay of local finance. • Not earmarked.
Severance Taxes	• Resource owners bear the burden. • Consuming states perceive the tax as being an unfair exploitation by producing states.	• Severance taxes replace property taxes: shift the burden to the act of severing and eliminate the resource from the property tax base. • The high cost of severing is the decrease in wealth.	• Largest yield in oil and gas taxes. • Not significant except in a few oil producing states. • Fluctuates with oil and gas prices.	• Viewed as a barrier to production when price levels do not allow profits.	• Costly because of the variety of taxed resources and the difficulty to distinguish between profitable production and marginal production; rates are not uniform.	• Designing a tax such as to maximize revenues without discouraging production is difficult.

Table 11-2. Summary of Evaluation Criteria for Non-User Fees. (Continued)

NON USER FEES (CONTINUED)	EQUITY	EFFICIENCY	REVENUE POTENTIAL	ACCEPTABILITY	ADMINISTRATIVE FEASIBILITY	APPLICABILITY
Income Taxes	• Ability to pay has no relationship with benefits; equity problem.	• Distortions exist from exemptions and exclusions.	• Major revenue source for federal and state governments. • Indirect access to revenues for highways through general funds.	• Widely accepted because it is based on the ability to pay. • Difficulty of defining taxable income.	• Possible evasion because of exemption rules. • The tax is "in place" but reforms are continuously proposed.	• The major problem for application is the difficulty of defining taxable income.
Gambling Taxes	• Fair because payment is voluntary.	• Distributional issue; low income people tend to spend more on lotteries than high income people.	• Not likely source for transportation revenue.	• Relatively popular (especially lotteries). • The idea of gambling always faces objections.	• Varies among states and different regulations for different measures.	• Possible legal impediments at the interstate level and use of the mail.

Table 11-3. Summary of Evaluation Criteria for Special Benefit Fees

	CRITERIA					
	Basic Evaluation			Practical Considerations		
SPECIAL BENEFIT FEES	EQUITY	EFFICIENCY	REVENUE POTENTIAL	ACCEPTABILITY	ADMINISTRATIVE FEASIBILITY	APPLICABILITY
Impact Fees	• Apportionment of the fees among new users or all users raise equity considerations.	• May raise costs of development.	• Function of the quantity of new development. • Fluctuates with the level of new construction; hard to predict. • Responsive to inflation and growth.	• Frequent litigation. • Not inherent to the fees but rather to the opposition to tax increases.	• Complicated. • Placed in special trust funds.	• Applied by local government. • Effective in high growth areas. • Legality varies among states. •Three general rules where applicable: 1) New development has to require facilities expansion 2) Fees must not exceed costs 3) Revenues spent only on the required expansion.
Special Assessments	• Same as for impact fees.	• Costs of improvements paid by the benefiting area with no need for tax increase.	• Limited to the willingness to apply assessments and the requirement that the property value increases by the assessment amount. • When costs rise action should be taken by the jurisdictions to increase assessments.	• Opposed by payers.	• Less complex than impact fees but more complicated than general taxation (requires special tax rolls and the receipts are placed in special funds.)	• Applied by special districts. • Applied in areas where improvements increase property values. • States give authority to local government to impose special assessment.
Tax Increment Financing	• Since created to improve depressed areas and therefore imposed on disadvantaged people the tax is seen as "unfair".	• Raises money for infrastructure development without tax increase.	• Small yield. • Uncertain flow of funds.	• Risk on bond holders is high; accepted when risk is compensated by higher returns.	• Many restrictions placed on its use.	• Evolved in urban areas. • Marketing tax increment bonds is difficult.

Table 11-4. Summary of Evaluation Criteria for Private Financing.

	EQUITY	EFFICIENCY	REVENUE POTENTIAL	ACCEPTABILITY	ADMINISTRATIVE FEASIBILITY	APPLICABILITY
PRIVATE FINANCING	• The allocation of highway development costs between the private and public sectors creates equity problems. • Negotiated agreements provide advantages in this respect as compared to the mandatory fee approach. • Voluntary contributions result in inequity among low growth and high growth areas.	• Private partcipation introduces competition, leading to lower operational costs.	• Unpredictable, hard to integrate in long term transportation planning. • Promotional policies are not enough to generate a stable funding base. • Leasing/selling arrangements generate a more steady and dependable cash flow. • Donations are tied to a single project; unpredictable.	• Negotiated agreements are well accepted when property rights are preserved. • Joint responsibility is attractive to developers seeking long term competitive advantages. • State governments may perceive private contributions as a disadvantage: private funds cannot be used as a state's matching share on federal-aid highway projects and thus contributions reduce reimbursements of proportional costs paid by the federal government.	• Complex because of state and federal regulations. • Projects receiving federal support are subject to costly and time consuming procedures. • Small government entities need state agencies' technical and administrative assistance.	• Most common and most successful in areas where the private sector has a strong interest in development. • When regulations are too restrictive developers may choose to locate elsewhere. • Since private and public funds are combined, liability issues (i.e., designating legal responsibility) may arise.

Table 11-5. Summary of Evaluation Criteria for Debt Financing.

	Equity	Efficiency	Revenue Potential	Acceptability	Administrative Feasibility	Applicability
DEBT FINANCING	• With revenue bonds, project users bear the full cost of financing.	• Speed up construction and payment on highway projects.	• Balancing debt financing with other revenue sources is necessary. • Important source, but over borrowing may lead to a lack in revenues for current maintenance and construction spending.	• Revenue bonds are popular because less risky and does not require voter approval. • Negotiated bonds are attractive for their flexibility to variations in interest rates. • Citizens are skeptical of debt financing: high interest payments perceived as evidence that they are paying more than the value of projects. • The political appeal of specific large new projects helps to overcome legislative problems.	• Financial expertise is needed for the management of new debt instruments. • State or local regulation requirements may be costly.	• Depends on the state financial position and level of indebtedness. • Most appropriate for catching up on large capital needs. • More appropriate in high growth areas able to meet debt requirements.

APPENDIX A: AVIATION REVENUE SOURCES

In the United States, airports - like roads and streets - usually are not federally owned and operated:

> The large and small *commercial airports*, which offer cargo and passenger airline service, are owned primarily by municipalities or special authorities and by 13 states. A relative handful of these facilities handle most commercial airline passengers - almost one-quarter of total passengers board flights at just five airports. ... Of the over 17,000 airports in the United States, most are public-use *general aviation (GA) airports* owned by municipalities, counties, or private groups and used primarily by personnel and business aircraft... .
>
> The concentration of commercial passengers at major airports permits them to be largely self-supporting from landing fees, airline rents, and revenues from parking and concessions. Management and oversight of ground side facilities differs drastically from airport to airport. Airlines typically lease terminals and gates from the airport operator, obtaining exclusive-use rights, and the major lessors often gain a strong voice in decisions on whether and how to expand ground facilities. ....
>
> Medium and small airports rely on Federal or State help in meeting their funding needs. Almost all States have airport aid programs, usually targeted to smaller, non-metropolitan airports, and most maintain statewide airport development plans.Funds come from State aviation fuel taxes and general appropriations.[217]

Federal Aviation Taxes

The Federal Aviation Administration spends several billion dollars per year, mostly to build and operate the air traffic control system, including funds for building and improving airports.

> Federal aid to aviation dates back to the 1920s, when Post Office contracts were used to encourage the fledgling commercial aviation industry. Federal acquisition of air traffic control centers from private and local operators began in the mid-1930s, with nationalization of major airport terminal control towers occurring in 1941. This system now includes nearly 900 towers and other facilities and more than 14,000 air traffic controllers. In 1946, believing that an adequate system of airports was a matter of national concern both for defense reasons and because of the rapid growth expected for civilian aviation, the Congress authorized a program of federal grants to help finance construction of airports.[218]

User taxes finance federal capital spending on airports and air traffic control as well as

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[217] Office of Technology Assessment, Congress of the United States, *Delivering the Goods*, Washington D.C, U.S Government Printing Office, April 1991, p. 119-120.

[218] Congressional Budget Office, *Financing U.S Airports in the 1980s*, Washington D.C, U.S Government Printing Office, July, 1985, p. 27-28.

a portion of FAA operating expenditures. These taxes which originated in 1933 and 1941, were not formally linked to expenditures until 1970, when the Airport and Airway Trust Fund was established. In 1985, about 87 percent of the tax receipts paid into this fund will be provided by an 8 percent tax on domestic passenger tickets. The balance is provided by a tax of 14 cents per gallon on general aviation (noncommercial) jet fuel (12 cents for gasoline) and taxes on freight waybills and international passenger travel.[219]

Funds for aviation at the federal level come both from user taxes and from allocations from general funds. The federal government imposes a 12 cents per gallon tax on aviation gasoline and a 14 cents per gallon tax on jet fuel used in general aviation aircraft; fuel used by commercial carriers is not taxed.

The federal government also imposes a registration fee tax on civil aircraft equal to $25.00 plus, for non-turbine powered aircraft weighing more than 2,500 pounds, two cents per pound for each pound of the maximum certified takeoff weight, or for turbine powered aircraft, 3.5 cents per pound of the maximum certified takeoff weight.

In addition, there are several other federal aviation taxes: an eight percent passenger ticket tax, a five percent air freight waybill tax, and a $3.00 international departure fee levied on passenger and air cargo carriers. The 1990 budget agreement permits airports to levy a $3.00 per person charge for airport improvements.

A formula based on passenger volume is used to distribute about 60 percent of federal grants for airport improvement to airports. The remaining funds are distributed for special needs in the form of discretionary grants.

State Aviation Revenue Sources in the United States

All states except Texas impose one or more state aviation taxes, including aviation fuel taxes, aircraft registration fees, and pilot registration fees. Some states also generate revenue by operating state owned airports. The two principal sources of revenue for aviation use are aviation fuel taxes and airplane registration fees. The National Association of State Aviation Officials recently surveyed state aviation officials about the types of aviation taxes used in each state.[220] The results of this survey were obtained and summarized, and are presented in Tables A-1 and A-2. Table A-1 gives a summary of types of aviation revenue for state government. The first four columns show the status of fuel excise taxes by state. The first column has an "x" beside a state's name if the state has an excise tax on aviation gasoline ("avgas") and an "x" in the second column if the tax is dedicated to aviation use. The third and fourth columns provide similar information for jet fuel. The fifth column indicates whether a state requires aviation registration fees, and the sixth column indicates the percent of registration fees that are dedicated to aviation. The last column indicates whether the states have other revenue sources besides

[219] CBO, July, 1985, p. 28.

[220] National Association of State Aviation Officials, *1992 State Aviation Tax Revenue Report*, Silver Spring, Maryland, Center for Aviation Research and Education, 1992.

aviation fuel excise taxes and registration fees.

Aviation fuel taxes are the primary source of revenues for state funded aviation programs, and are imposed either as an excise tax, typically in cents per gallon, or as a general sales tax, imposed as a percent of the sales price. Table A-2 provides a more detailed look at aviation fuel taxes; the first four columns give the aviation fuel excise tax rates and percent dedicated. The last four columns give the state sales tax on aviation fuels and the percent dedicated to aviation. States usually have either an excise tax on aviation fuels or a sales tax on aviation fuels, but several states have differing combinations of both types of fuel taxes.

The excise tax rate usually is a single, constant rate, but this rate varies considerably from state to state. In addition, several states have excise rates that vary either by gallons purchased per year or vary for different geographic regions of the state. Some states have considerably higher excise tax rates for aviation gas than for jet fuel. However, the states that have a sales tax on aviation fuel usually charge the same rate for jet fuel as for aviation gas.

Four states, Michigan, New York, Tennessee, and Washington, have both an excise and a sales tax on both aviation gasoline and jet fuel. Michigan and Washington dedicate both aviation fuel excise taxes but neither fuel sales tax to aviation; Tennessee dedicates sales taxes on both fuels but does not dedicate either excise tax.

One state, Maine, has an excise tax on both fuels but has a sales tax only on aviation gas, and dedicates none of these taxes to aviation. Two states, California and Colorado, have an excise tax on both fuels but have a sales tax on only jet fuel. California dedicated only the excise taxes to aviation, whereas Colorado dedicates all three taxes to aviation.

Twenty-five states have excise taxes on both aviation gas and jet fuel but have no sales tax on either fuel. These states are Alabama, Alaska, Arizona, Florida, Hawaii, Idaho, Iowa, Massachusetts, Minnesota, Mississippi, Montana, Nebraska, Nevada, New Hampshire, New Jersey, North Dakota, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Dakota, Utah, Virginia, Wisconsin, and Wyoming. The majority of these states dedicate all of these excise tax revenues to aviation, but several have no dedication, and some have partial dedication.

Table A-1. State Aviation Revenue Sources, 1991

	Fuel Excise Taxes				Registration Fee	Dedicated to Aviation (%)	Other
	Aviation Gasoline	Dedicated	Jet Fuel	Dedicated			
ALABAMA	X	X	X	X			X
ALASKA	X		X				X
ARIZONA	X	X	X		X	100	X
ARKANSAS							X
CALIFORNIA	X	X	X	X			X
COLORADO	X	X	X	X			X
CONNECTICUT							X
DELAWARE	X						
FLORIDA	X	X	X	X			X
GEORGIA	X						X
HAWAII	X	X	X	X	X	100	
IDAHO	X	X	X	X	X	100	X
ILLINOIS					X	100	X
INDIANA	X				X	0	X
IOWA	X		X		X	100	X
KANSAS							X
KENTUCKY	X						X
LOUISIANA							X
MAINE	X		X		X	100	X
MARYLAND	X						X
MASSACHUSETTS	X	X	X		X	50	X
MICHIGAN	X	X	X	X	X	100	X
MINNESOTA	X	X	X	X	X	100	X
MISSISSIPPI	X	X	X	X	X	0	X
MISSOURI	X	X					X
MONTANA	X	X	X	X	X	10	X
NEBRASKA	X	X	X	X			X
NEVADA	X	X	X				X
NEW HAMPSHIRE	X		X		X	0	X
NEW JERSEY	X	X	X	X			X
NEW MEXICO	X	X			X	100	X
NEW YORK	X		X				X
NORTH CAROLINA							X
NORTH DAKOTA	X	X	X	X	X	100	X
OHIO					X	0	X
OKLAHOMA	X		X		X	97	X
OREGON	X	X	X	X	X	100	X
PENNSYLVANIA	X	X	X	X			X
RHODE ISLAND	X		X		X	0	X
SOUTH CAROLINA							X
SOUTH DAKOTA	X	X	X	X	X	100	X
TENNESSEE	X		X				X
TEXAS							X
UTAH	X	X	X	X			
VERMONT	X						X
VIRGINIA	X	X	X	X	X	100	X
WASHINGTON	X	X	X	X	X	100	X
WEST VIRGINIA							X
WISCONSIN	X		X		X	0	X
WYOMING	X	X	X	X			X

Source: National Association of State Aviation Officials, Center for Aviation Research and Education, *1992 State Aviation Tax Revenue Report*, Silver Spring, Maryland, 1992.

Table A-2. Summary of State Excise and Sales Taxes on Aviation Gasoline and Jet Fuel, 1991

	Fuel Excise Taxes ($/gallons)				Applied State Sales Taxes (%)			
	Aviation Gas	Dedicated to Aviation (%)	Jet Fuel	Dedicated to Aviation (%)	Aviation Gas	Dedicated to Aviation	Jet Fuel	Dedicated to Aviation
ALABAMA	0.038	100	0.017	100	None	N/A	None	N/A
ALASKA	0.04	0	0.025	0	None	N/A	None	N/A
ARIZONA	0.05	100	0.0305	0	None	N/A	None	N/A
ARKANSAS	None	N/A	None	N/A	4	Yes	4	Yes
CALIFORNIA	0.16	100	0.02	100	None	N/A	7.25	No
COLORADO	0.06	100	0.04	100	None	N/A	3	Yes
CONNECTICUT	None	N/A	None	N/A	2.5	No	2.5	No
DELAWARE	0.19	0	None	N/A	None	N/A	None	N/A
FLORIDA	0.069	100	0.069	100	None	N/A	None	N/A
GEORGIA	0.01	0	None	N/A	4	No	4	No
HAWAII	0.01	100	0.01	100	None	N/A	None	N/A
IDAHO	0.055	100	0.045	100	None	N/A	None	N/A
ILLINOIS	None	N/A	None	N/A	6.25	No	6.25	No
INDIANA	0.15	0	None	N/A	5	No	5	No
IOWA	0.08	0	0.03	0	None	N/A	None	N/A
KANSAS	None	N/A	None	N/A	4.25	No	4.25	No
KENTUCKY	0.15	0	None	N/A	None	N/A	6	No
LOUISIANA	None	N/A	None	N/A	3	Yes	4	Yes
MAINE	0.19	0	0.034	0	6	No	None	N/A
MARYLAND	0.07	0	None	N/A	None	N/A	None	N/A
MASSACHUSETTS	0.1	80	0.1	0	None	N/A	None	N/A
MICHIGAN	0.03	100	0.03	100	4	No	4	No
MINNESOTA	(1)	100	(1)	100	None	N/A	None	N/A
MISSISSIPPI	0.064	100	0.0525	100	None	N/A	None	N/A
MISSOURI	0.09	100	None	N/A	None	N/A	4.225	No
MONTANA	0.01	100	0.01	100	None	N/A	None	N/A
NEBRASKA	0.05	100	0.03	100	None	N/A	None	N/A
NEVADA	0.18	100	0.01	0	None	N/A	None	N/A
NEW HAMPSHIRE	0.04	0	(2)	0	None	N/A	None	N/A
NEW JERSEY	0.125	100	0.02	100	None	N/A	None	N/A
NEW MEXICO	0.16	100	None	N/A	None	N/A	(3)	Yes
NEW YORK	0.08	0	0.1	0	(4)	No	(4)	No
NORTH CAROLINA	None	N/A	None	N/A	4	Yes	4	Yes
NORTH DAKOTA	0.08	100	0.08	100	None	N/A	None	N/A
OHIO	None	N/A	None	N/A	5	No	5	No
OKLAHOMA	0.0008	0	0.0008	0	None	N/A	None	N/A
OREGON	0.03	100	0.005	100	None	N/A	None	N/A
PENNSYLVANIA	0.038	100	0.02	100	None	N/A	None	N/A
RHODE ISLAND	0.26	0	0.26	0	None	N/A	None	N/A
SOUTH CAROLINA	None	N/A	None	N/A	5	No	None	N/A
SOUTH DAKOTA	0.06	96	0.04	96	None	N/A	None	N/A
TENNESSEE	0.01	0	0.01	0	4.5	Yes	4.5	Yes
TEXAS	None	N/A	None	N/A	None	N/A	None	N/A
UTAH	0.04	100	0.04	100	None	N/A	None	N/A
VERMONT	0.15	0	None	N/A	None	N/A	5	No
VIRGINIA	(5)	(5)	(5)	(5)	None	N/A	None	N/A
WASHINGTON	0.06	100	0.06	100	6.5	No	6.5	No
WEST VIRGINIA	None	N/A	None	N/A	5	Yes	5	Yes
WISCONSIN	(6)	0	(6)	0	None	N/A	None	N/A
WYOMING	0.05	80	0.05	80	None	N/A	None	N/A

Notes:

(1) Sliding tax rate: 0-49,999 gallons is $0.05
50,000-149,999 gallons is $0.02
150,000-199,999 gallons is $0.01
Over 200,000 gallons is $0.005

(2) $0.025 excise tax on part 121 Air carriers, $0.02 excise tax on all others.

(3) Sliding tax rate from 4.75% to 5.75% depending on the county in which the fuel is purchased.

(4) Sliding tax rate from 4% to 8.25% depending on the county in which the fuel is purchased.

(5) Sliding tax rate: Under 100,000 gallons, $0.05 per gallon tax with 80% dedicated to aviation
Over 100,000 gallons, $0.005 per gallon tax with 50% dedicated to aviation

(6) $0.055 or 3% depending on which is higher.

Source: National Association of State Aviation Officials, Center for Aviation Research and Education, 1992 State Aviation Tax Revenue Report, Silver Spring, Maryland, 1992.

Two states, Georgia and Indiana, have an excise tax on aviation gasoline and also have a sales tax on both fuels. Neither dedicate any of the three taxes to aviation. Four states, Kentucky, Missouri, New Mexico, and Vermont, have an excise tax on aviation gasoline and a sales tax on jet fuel. New Mexico dedicates all of its excise tax on aviation gas and all of its sales tax on jet fuel to aviation. Missouri dedicates its aviation fuel excise tax to aviation but does not dedicate its sales tax on jet fuel. Kentucky and Vermont dedicate neither of their taxes.

Two states, Delaware and Maryland, have an excise tax only on aviation gasoline and no sales tax on either aviation fuel. Neither state dedicates this revenue to aviation.

Eight states have a sales tax on both fuels and no excise tax on either. These states are Arkansas, Connecticut, Illinois, Kansas, Louisiana, North Carolina, Ohio, and West Virginia. Four of these states - Arkansas, Louisiana, North Carolina, and West Virginia - dedicate all of both sales taxes to aviation, but the other four states do not dedicate either.

South Carolina has a sales tax only on aviation gasoline and no excise tax on either aviation fuel. The sales tax on aviation gasoline is not dedicated to aviation. Texas is the only state that has neither an excise tax nor a sales tax on aviation fuel.

In some states, the tax on Jet A fuel is a major source of general revenue, generating approximatley $100 million in California in FY91, for example.

State Aviation Fuel Taxes - Summary

Overall, thirty-two states have excise taxes on both aviation gas and jet fuel. For these states, the excise tax on aviation fuel ranges from typical lows of one cent per gallon in Montana and Hawaii to a high of 26 cents per gallon in Rhode Island. However, sixteen of the thirty-two states have rates ranging from four to eight cents per gallon. Twenty-three of these 32 states dedicate at least part, and usually 100 percent, of their aviation excise taxes to aviation. Most of these 32 states have the same or similar excise tax rates on both aviation gasoline and jet fuel, but several charge a much higher rate on aviation gasoline. For example, Nevada's rate on avgas is 18 cents per gallon but on jet fuel is only one cent per gallon. California has a 16 cent rate on avgas but only 2 cents on jet fuel, but the avgas is exempt from the sales tax whereas jet fuel has a sales tax rate of 4.25 percent; both of the excise taxes are dedicated to aviation but the sales tax is not. Rhode Island charges the highest rate on both, 26 cents per gallon.

Eight states have excise taxes only on aviation gasoline, but these states often have higher tax rates than do the states that tax both fuels; five of the eight states have rates of fifteen cents or higher per gallon; only two of the eight dedicate their excise tax to aviation.

Nine of the 22 states having a sales tax on aviation fuel do not also have any aviation excise tax on at least one aviation fuel. Four of these nine dedicate all of their sales tax revenue to aviation. It appears that the sales tax rates, for the 22 states having them, are the same as the sales tax on other items in the state, and this rate usually is around four or five percent, with a low of 2.5 percent in Connecticut and a high of 8.25 percent in some counties in New York.

Thirteen of the fourteen states that have a sales tax on aviation fuel charge the same percent for both; the exception, Louisiana, has a three percent sales tax on avgas and a four percent tax on jet fuel.

Only one state, Texas, has no state tax on either aviation fuel. (As discussed later below, Texas did have an excise tax on aviation fuels of five cents per gallon from 1966 to 1978.)

Other State Aviation Revenue Sources

Pilot and Aircraft Registration Fees

Eight states charge *pilot registration fees* and 23 charge *aircraft registration fees*, as shown in Table A-3.[221] Seven of the eight states with pilot registration fees dedicate 100 percent of this revenue to aviation. The annual revenue derived from this source is relatively small, ranging from a low value of $7,032 in North Dakota to a high of $99,761 in Illinois. Fourteen of the 23 states that charge fees for aircraft registration dedicate all of this revenue to aviation. One state dedicates 10 percent to aviation, one dedicates 50 percent, and another dedicates 90 percent, while six do not dedicate any of the aircraft registration fees to aviation. The annual revenue from aircraft registration fees ranges from $1,035 in Maine to $1,382,8335 in Indiana, none of which is dedicated to aviation.

Sales Tax on Aircraft and/or Aircraft Parts

According to the survey of state aviation agencies, 36 state aviation agencies (not including Texas) list sales taxes on aircraft and/or aircraft parts as sources of aviation revenue but 32 of these do not dedicate the revenue to aviation. Given that Texas has a sales tax on aircraft and aircraft parts that is generating revenues equal to over four times the amount transferred from the general fund to aviation, this tax presumably could be listed as a non-dedicated aviation tax in Texas just as justifiably as in the 32 other similar states.

North Carolina dedicates its 4 percent tax on aircraft and/or parts to aviation but the amount of revenue generated was not specified. South Dakota dedicates its 4 percent sales tax on aircraft and/or parts to aviation generating $368,200 in FY91 whereas North Dakota generated $342,000 dedicated to aviation. Virginia dedicated its 2 percent tax on aircraft and/or parts sales to aviation generating $2,423,540 in FY91.

[221] National Association of State Aviation Officials, *1992 State Aviation Report*, Silver Spring, Maryland, Center for Aviation Research and Education, 1992, p. 22.

Table A-3. **Pilot and Aircraft Registration Fees, 1991**

State	Pilot Registration Fees		Aircraft Registration Fees	
	Dedicated to Aviation (%)	1991 Amount	Dedicated to Aviation (%)	1991 Amount
Arizona	-	-	100 %	$47,410
Hawaii	-	-	100	4,760
Idaho	100 %	$39,000	100	68,246
Illinois	100	99,761	100	62,420
Indiana	-	-	0	1,382,835
Iowa	-	-	100	991,606
Maine	-	-	100	1,035
Mass.	-	-	50	294,953
Michigan	-	-	100	221,909
Minnesota	-	-	100	1,200,000
Miss.	-	-	0	200,000
Montana	100	19,247	10	240,275
New Hamp.	0	14,071	0	46,509
New Mexico	-	-	100	74,387
No. Dakota	100	7,023	100	61,160
Ohio	-	-	0	116,000
Oklahoma	-	-	97	288,403
Oregon	100	39,788	100	189,364
Rhode Is.	-	-	0	17,505
So. Dakota	100	7,385	100	19,150
Virginia	-	-	100	12,092
Washington	100	66,280	100	19,056
Wisconsin	-	-	0	327,110

Source: National Association of State Aviation Officials, *1992 State Aviation Tax Revenue Report*, Silver Spring, Maryland, NASAO Center for Aviation Research and Education, 1992, p.22.

Miscellaneous Sources

Other revenue sources noted by the states include interest income, property leases of aeronautic department land or building space, tiedown fees, landing fees, flight property tax, various revenues from state owned airports, personal property tax on aircraft, sales of publications, airport licensing, state aircraft leasing, airport inspection payments, aerial sprayer licenses, aircraft dealer licenses, and flight recertification courses.

Some of the miscellaneous sources of revenue are quite significant in a few states. Minnesota generated $12 million of its $12.6 million state aviation funding from a state "aircraft tax." Pennsylvania generated $7.7 million of its $18.7 million state aviation budget from revenues from three state owned airports. In Connecticut, the personal property tax, although not dedicated to aviation, generated $2,653,043 as compared to the state aviation budget of $2,798,272 in FY91; the 2.5 percent sales tax on Avgas, Jet A fuel, and Mogas generated $4,659,622 in the same year, also not dedicated to aviation.

In Arizona, with a state aviation budget of $15 million, $10.6 million was generated by a "flight property tax," $1.4 million from interest income, $1.4 million from an "aircraft tax," and $1 million from state owned airport; all of these revenues were dedicated 100 percent to aviation.

State Aviation Role and Taxes in Texas

Aviation fuel was taxed in Texas from 1966 to 1978 at five cents per gallon, which was the same rate as the highway gasoline tax during that time period. The aviation fuel tax was refunded if the user filed a claim accompanied by invoices of exemption. Any unclaimed aviation fuel tax was credited to the Texas Aeronautics Commission (75 percent) and the Available School Fund (25 percent). Approximately $600,000 was credited to the Aeronautics Commission for aviation facility improvements.

There probably were several reasons for repealing the state aviation fuels tax in 1980. During the 1970s and early 1980s when the state had extra money in the general fund, it was possible to fund aviation expenditures from general revenues. However, in recent years, with shortages of general funds to meet the many demands for funding in a tight state budget, it has been increasingly difficult to obtain funds for aviation expenditures from general revenues. Prior to 1987, the state put about $1 million per year into the state airport system. This relatively small program was discontinued in 1987 when all funding for the airport facilities development program was canceled by the state legislature during the state budget crisis.[222] Total state funding from the general fund decreased from $1,199,382 in FY87 to $978,774 in FY88 and to $878,855 in FY89 before increasing to $2,741,159 in FY90 and $4,400,000 in FY91.

The only revenue sources other than general revenue shown in a recent summary of aviation finance in Texas (apparently for FY91) were: $40,453 from flight instruction recertification courses; $11,042 from interest income; and $4,899 from sale of publications, all of which were 100 percent dedicated to aviation.

Table A-4 shows consumption of aviation gasoline and jet fuel in Texas over the last 31 years from 1960 through 1990. This shows that sales of aviation gasoline have declined from about 137 million gallons per year in 1960 to about 35 million gallons per year in 1990. Annual consumption of jet fuel in Texas over the same period rose from about 455 million gallons to about 4,028 million gallons. Therefore, in Texas, gallons of jet fuel consumed are over 100

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[222] Texas Aeronautics Commission, *Texas Aeronautical Facilities Plan, Summary*, Austin, Texas, October, 1988.

times as much as the gallons consumed of aviation gasoline. Therefore, enacting an excise tax on both fuels, even with a relatively low rate on jet fuel, would produce more revenue than an excise tax on aviation gasoline alone. Another alternative would be to extend the state sales tax to aviation gasoline and jet fuel and to dedicate this to an aviation improvement fund. Using the sales tax approach would have the advantage of avoiding the necessity of a new tax. Of course, various other fees could be considered, but the aviation fuel tax would have the advantage of charging more in relation to use.

Texas is currently the only state that does not apply the principle that aviation users should pay for state aviation expenditures. This could be remedied by levying aviation fuel taxes possibly supplemented with airplane registration fees or some other fee.

Table A-4. Consumption of Aviation Gasoline and Jet Fuel, 1960-1990, Texas (Millions of Gallons)

Year	Aviation Gasoline	Jet Fuel
1960	137.0	455.4
1961	119.9	495.6
1962	163.1	589.9
1963	153.5	615.3
1964	141.5	650.9
1965	145.2	645.3
1966	126.5	741.1
1967	112.2	888.8
1968	93.4	1018.6
1969	91.9	1054.2
1970	84.3	1026.1
1971	83.9	1052.8
1972	65.7	1088.2
1973	65.3	1114.4
1974	67.3	1090.1
1975	55.1	1146.9
1976	53.3	1076.9
1977	57.2	1121.6
1978	53.7	1174.1
1979	49.4	1229.0
1980	53.1	1299.2
1981	54.6	1298.7
1982	37.9	1798.0
1983	32.0	1985.3
1984	40.4	2714.3
1985	55.3	3129.0
1986	64.6	3369.0
1987	48.3	3551.6
1988	42.5	3981.3
1989	34.4	3917.1
1990	35.2	4027.9

Source: U.S. Energy Information Administration, *State Energy Data Report 1960-1990*, U.S.GPO, 1992.

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APPENDIX B: USE OF ALTERNATE FUELS IN TEXAS

Use of different types of motor fuel has several implications for taxation. Historically, the principal question in differential taxation of alternate motor fuels centered around diesel as an alternate to gasoline for highway use. Other things being equal, diesel engines have tended to get better miles per gallon so there has been a need to have diesel taxes higher than gasoline taxes according to the equity principle that equals should be treated equally. With increasing air quality standards, most new passenger cars, pickups, and vans do not now use diesel, but, over the last thirty years, diesel has become the predominant fuel used in large intercity trucks. Texas once had a tax of six cents per gallon on diesel, as compared to a five cent tax on gasoline, that was primarily justified on the basis of intercity diesel trucks obtaining better fuel mileage than similar gasoline-powered trucks. Since diesel-powered trucks have become by far the predominant intercity trucks, the emphasis on equalizing intercity gasoline trucks with intercity diesel trucks has lessened, and this type of equalization has tended to be lost in the relative equity arguments of cars versus trucks. Nevertheless, an argument still can be made that diesel should be taxed at a higher rate than gasoline in treating gasoline trucks equally compared to diesel trucks.

Recent legislation encourages or mandates increased use of alternate fuels especially natural gas. In Texas, it appears that compressed natural gas (CNG) and liquified natural gas (LNG) will be the primary new alternate fuels that will be emphasized in the near future. At present the federal and Texas laws apply mainly to large fleets, and the Texas legislation mandates only certain percentages of vehicles by different points in time.

Federal and State Legislation

Recent legislation at the state and federal levels has promoted use of alternate fuels for various reasons, but mainly to promote economic stimulus for some fuels and to promote clean air goals. Alternate fuels were encouraged by the national *Alternative Motor Fuels Act of 1988*, which "... gave corporate average fuel economy credits to automakers for building clean fuels vehicles that did not operate on diesel or gasoline."[223] In addition, the Clean Fuels Fleet Program, established by the *Clean Air Act of 1990*, provided that centrally fueled fleets of ten or more vehicles must meet low-emission vehicle standards in serious ozone non-attainment areas. According to the act, fleets must start to purchase clean-fuels vehicles by 1998 and by the year 2000, 70 percent of all newly purchased light-duty and medium-duty vehicles must be clean-fuels vehicles.[224]

Texas state law dictates use of alternate fuels in public and private fleets, initially affecting state agency fleets with more than 15 vehicles, school districts with more than 50 vehicles, and private fleets with more than 25 vehicles, and all metropolitan transit agencies. These entities must convert at least 30 percent of their affected fleets to alternative fuels by September, 1994; 50 percent by September, 1996; and 90 percent by September, 1998. Smaller fleets may be regulated after 1998. This state law has lead most transit authorities, cities, state agencies, and private businesses to evaluate alternate fuels.

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[223]Keebler, Jack, "Natural Gas Leads Alternate Fuels,": *Automotive News*, August 3, 1992, p. 34.

[224]Keebler, 1992, p. 34.

Other possible State legislation includes stronger emissions regulations. Recently, in October 1992, the Highway Users Federation noted that they anticipate that there will be legislative or regulatory action in at least 15 states in 1992 to adopt California vehicle emission standards. The extent to which other states adopt the California standard will undoubtedly have a large impact on the switch to alternate fuels for environmental purposes.[225] Currently, the California emissions standards are: "0.39 gpm of hydrocarbons, 7.0 gpm of carbon monoxide, and 0.4 gpm of oxides of nitrogen. The ultra-low emissions standards, that take effect in 1997, are 0.04 gpm of hydrocarbons, 1.7 gpm of carbon monoxide, and 0.2 gpm of NOx."

Gasohol and Ethanol

Gasohol is partially exempt from federal motor fuel tax, and several states have legislation that promotes the use of gasohol, which is a mixture of about 90 percent gasoline and 10 percent ethanol, by having a lower tax on gasohol than on gasoline. These states are Alaska (8 cents for gasoline/0 cents for gasohol), Florida (15.2/11.2), Idaho (21/14), Iowa (20/19), New Jersey (10.5/4.5), South Carolina (16/10), South Dakota (18/16), and Wyoming (9/5).

In 1990, gasohol represented more than one percent of highway use of gasoline in thirty-one states and more than 10 percent in 13 states. The maximum percent was used in grain and corn-belt states with Nebraska leading all states in 1989 at 40.64 percent gasohol, followed by Iowa at 28.92 percent, and Illinois at 28.92 percent. In Texas, highway use of gasohol as a percent of gasoline was 5.07 percent in 1985 but gradually declined to 2.93 percent in 1990. Since gasohol is used and taxed in Texas in a way very similar to gasoline (except for the difference in the federal motor fuel tax), the effects on state-generated highway revenues are expected to be relatively insignificant in the foreseeable future.

The Highway Users Federation estimates that due to the federal motor fuel tax exemption, the Highway Trust Fund loses almost $400 million annually. In October, 1992, the White House proposed:

> to effectively guarantee a market for ethanol fuels in clean air non-attainment areas where they couldn't otherwise compete. The proposal directs oil companies to produce 'cleaner' gasoline so that ethanol can be added without producing more pollution. This would enable these blends to qualify as one of the reformulated fuels the Clean Air Act requires in the nine worst ozone non-attainment regions. This proposal would boost the cost of fuels because additional refining would be required."[226]

This also would lead to greater losses from the Federal Highway Trust Fund, estimated by the Highway Users Federation to be an additional $125 million per year.

Compressed and Liquid Natural Gas

A recent evaluation of alternate fuels published in *Automotive News* concluded that compressed natural gas was emerging as the leading alternate fuel. Natural gas has become the leading alternate fuel for several reasons. Utilities and natural gas umbrella organizations have

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[225]Highway Users Federation, letter dated October 26, 1992.

[226]Highway Users Federation, "Ethanol Fuels," in letter of October 26,1992.

been funding development efforts for CNG vehicles and have also been investing in CNG refueling stations. Also, EPA testing procedures are now favoring natural gas vehicles. The changes in testing procedure are described as follows:

> Beginning in 1994, EPA will stop testing for methane emissions. Methane is very stable and contributes little to ground-level ozone. EPA has reserved the right to resume testing for emissions, since they can contribute to global warming. But for now, it will be measuring only non-methane hydrocarbon emissions. Natural gas is primarily methane, and more than 90 percent of the hydrocarbon exhaust is methane.[227]

As a result, CNG is outdistancing other alternative fuels such as methanol; M-85, a mixture of 15 percent gasoline and 85 percent methanol; E-85, a mixture of 15 percent gasoline and 85 percent ethanol; and hydrogen. The *Automotive News* article concluded that "Unresolved concerns about emissions, supply systems, cost and toxicity seem to be slowing the move to M85 and other alternatives."[228] Keebler summarized the pros and cons of CNG-powered vehicles as follows.

> *Pros*: Natural gas vehicles can achieve an 85 percent reduction in carbon monoxide emissions, 30 percent reduction in oxides of nitrogen emissions and 90 percent reduction in active hydrocarbons. They emit no particulates. The output of reactive hydrocarbons that contribute to smog pollution is 85 percent less than that of gasoline. CNG is derived almost entirely from North American sources. Besides the energy used to compress and dry the gas, there are no high refining costs and or refining-related emissions. The delivery infrastructure is already largely in place. Roughly 1.2 million miles of pipeline supply the United States. The number of filling stations increased by 50 percent last year. The cost is reasonable; currently natural gas costs between 65 and 70 cents for the mileage equivalent of a gallon of gasoline.
>
> *Cons*: A poor driving range is frequently cited as a major drawback. In a passenger car, two cylinders of gas give a range of roughly 200 miles. With more fuel storage in a light-duty or medium-duty truck, a range of 300 miles is achievable. Vehicle conversion costs are high, from $1,500 for a simple conversion on a passenger vehicle to $3,500 for a sophisticated system on a large truck. EPA sources say that relatively high levels of oxides of nitrogen can be produced from a CNG vehicle, depending upon how the vehicle is adjusted. For example, if high compression ratios are used to take advantage of the fuel's 130 octane number, NOx emissions increase.[229]

Methanol

Methanol has several disadvantages relative to natural gas. It costs 70 cents more per gallon than gasoline, and in addition to being very toxic and being very corrosive (requiring premium materials for storage facilities) , it has major emissions problems, with high amounts of formaldehyde emissions. Methanol has cold start problems because of the lower vapor pressure. It also has many more distribution problems than does natural gas and the current supply of methanol is limited.

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[227]Keebler, 1992, p. 34.

[228]Keebler, 1992, p. 3.

[229]Keebler, 1992, pp. 3, 34.

Fleet Use of Alternate Fuels

Metropolitan Transit Authorities

Transit authorities in Texas and other states are testing alternative fuel vehicles to replace diesel, and the leading fuel is compressed natural gas (CNG), with liquified natural gas (LNG) also receiving increasing attention, according to a recent surveys.[230]

Compressed Natural Gas (CNG)

Flexible Corporation produced and delivered the first natural gas-powered bus to Fort Worth, Texas in September, 1989, and Fort Worth now has 12 CNG buses in operation and 36 on order. Other cities with new Flexible CNG buses include Newark, Miami, St. Louis, Dallas, and San Diego. According to Flexible representatives, the principal problem encountered with the first CNG buses was that the buses ran out of fuel after 10 hours of operation whereas transit companies needed buses that could run over 13 hours. This problem was resolved by adding additional fuel tanks to the buses; nevertheless, the space required for enough tanks for a bus to operate for 13 hours is substantial and one of the disadvantages of CNG.

The Central Oklahoma Transportation and Parking Authority (COTPA) in Oklahoma City began testing CNG powered vehicles in January 1990 when they took delivery of four 30-foot national coaches and converted 12 service vehicles to operate on CNG and gasoline. The original National coaches were delivered with two tanks that provided an operating range of less than 100 miles between refuelings. Four more tanks were added to each bus to increase their range to about 175 miles, but the total weight of the tanks, brackets, and hardware was nearly 1,200 pounds. COTPA also had numerous operational and maintenance problems with the converted engines that were on these buses. Many of the problems were related to the pressurized fuel systems being sensitive to changes in temperature, humidity, and atmospheric pressure. COTPA's decision to switch to CNG was partially made on the basis of CNG costing about 33 cents per gallon in Oklahoma City as compared to 65 cents per gallon for diesel. Despite numerous problems, COTPA remains committed to using natural gas. In the next phase of introducing natural gas, COTPA plans to use new engines that are designed to operate only on natural gas, both CNG and LNG.

Toronto also has been a leader in the use of CNG and has had 25 CNG Orion V buses in operation since January 1992. This bus uses a CNG-powered Cummins L10 engine. This engine recently was certified by the California Air Resources Board to 2.0 grams per brake horsepower hour (g/bhp.h) NOX and 0.02 g/bhp.h particulates, which not only meets the 1993 California standards but also the 1994 standard.

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[230]Information on transit use of alternate fuels is taken from Tara Parker, "Metro's switch to LNG bucks trend," *Houston Chronicle*, Wednesday, September 9, 1992, pp. 13A-19A; Donald Sabath, "Bus maker takes a new fuel route: Flexible Corp. builds vehicles using compressed natural gas," *Houston Chronicle*, June 28, 1992, p. 11G; "Battery Powered Buses Top Denver Clean Air Effort," *Passenger Transport*, September 7, 1992, p. 6; "Toronto's CNG-Powered Fleet Accumulates 1 Million Miles," *Passenger Transport*, September 7, 1992, pp. 5, 12; Pope, "Dayton Goes Back to the Future with Electric Trolley Buses," *Passenger Transport*, September 7, 1992, p. 8; "Oklahoma City Tests CNG-Fueled Buses," *Passenger Transport*, September 7, 1992, pp. 7, 13.

Liquified Natural Gas (LNG)

In addition to compressed natural gas, several cities are currently showing increased interest in liquified natural gas (LNG), which is created by cooling natural gas to about 258 degrees below zero. LNG has at least two advantages over CNG: first, the fuel tanks are much smaller for LNG, which is especially important for buses that need a large amount of natural gas to avoid the long refueling time during the work day; second, LNG burns even cleaner than CNG.

Houston Metro has been a leader in use of LNG since deciding two years ago to convert their 1,000 bus fleet to LNG. If ordered buses had been delivered on schedule, Houston Metro would currently have 200 LNG buses in operation. Because of delays in delivery, Metro currently has only 14 LNG vehicles in operation, most of which are mini-buses or retrofit diesels. They recently took delivery of their first full-size, 40-ft. LNG bus and are the only transit agency in the country using LNG. Metro is expecting delivery of 140 LNG-powered buses of various sizes during 1992 and an additional 240 LNG buses during 1993 and 1994.

The introduction of LNG buses by Houston Metro was delayed primarily because its largest LNG contract, with Ikarus USA, had difficulties when the Hungarian-based company manufacturing the buses lost its financial backing. These problems have apparently been resolved and Metro expects delivery of 1992 buses only slightly behind schedule. In addition, a California company that refused to bid on Metro's first orders recently contacted them and indicated that they now are committed to LNG for use in buses. According to Houston Metro, natural gas buses cost from $10,000 to $40,000 more than diesel buses but are about 40 percent cheaper per mile to operate. Other transit authorities have become interested and LNG buses have been ordered by Los Angeles; Gary, Indiana; Baltimore; and Portland, Oregon. Dallas Area Rapid Transit also is reportedly considering ordering some LNG buses.

Other fuels that are being used in North America include ethanol in Peoria, Illinois; CNG in Toronto; and methanol in Los Angeles. Electricity has been used previously in many cities and is currently is used in a trackless trolley bus system that has been in operation since 1933 in Dayton, Ohio. Dayton recently reversed an earlier decision to phase out this system, and they instead are going to refurbish it and add 61 new trolley buses in the 1992-94 period. New Orleans also has a trackless trolley bus system in addition to their well-known electric street car system.

Denver's regional Transportation District has been operating 26 battery-powered buses, some for as long as 10 years. This operation is characterized as a "mall shuttle fleet" and carries more than 45,000 people. These buses have the advantage of low point source emissions and quiet operation. However, the battery-powered buses have slow acceleration and a maximum speed of about 20 miles per hour. Also, they can only be operated for four hours and then have to be recharged for eight hours.

Overall, it appears that city transit authorities probably will switch a large number of their vehicles to CNG and LNG, and to a lesser extent to ethanol and methanol, over the next 10 years, unless current federal and state laws are changed. Some experts believe that hydrogen eventually will be used because of its desirable clean air properties, but it appears that extensive use of hydrogen is over 20 years away, barring major technological breakthroughs. This switching of transit vehicles to alternate fuels should have little effect on state transportation revenues.

Other Fleets

An extensive infrastructure is needed for fleets to use CNG, including CNG refueling stations, facilities for converting vehicles to CNG, and facilities for repairing CNG vehicles. Private industry has begun to provide this infrastructure in Texas, especially in Houston.

By November, 1992, at least 500 vehicles had already been converted to CNG in the greater Houston area, and industry sources projected that the number would double by the end of the year. About 25 to 30 of about 1,000 fleet operators in Houston had converted at least some of their vehicles to CNG.

In the early 1980s, *Entex* installed private CNG refueling pumps at a company facility in Houston, and Entex now operates about 150 CNG powered vehicles in its three state territory including Texas. At least two new companies have been formed in Houston for providing the public with CNG fuel and services: Enfuels and American National Gas Power (AMGP).

Enfuels, which is a joint venture of Enron Corp, Entex Inc., and Trenfuels, a subsidiary of Transco Energy Co., first began operating public CNG pumps in July, 1992 at a Galleria-area Chevron service station. In October, 1992 Enfuels opened a second outlet and also opened a 10-bay technology center in Houston for converting vehicles to CNG and for performing maintenance and repair work on CNG vehicles. The center also will "... train fleet managers and mechanics on CNG technology and serve as a general source of information on CNG".[231]

Enfuels plans to spend $10 million over the next five years for a network of CNG stations in the Houston area. They plan to have six stations open by the end of 1992, 12 to 15 by the end of 1993, and 100 public and 25 private CNG stations by the year 2005. They plan "... to install compressors, storage facilities and dispensers at existing service stations strategically located in downtown, near the airports and adjacent to busy freeways and intersections, as well as at refueling facilities operated by large fleet operators."[232]

Because of the high cost for each refueling station, ranging from $200,000 to $500,000, some public fleets may refuel at pay stations. The City of Houston "... recently signed a multiyear CNG fleet refueling contract with Enfuels, so that city's vehicles can gas up at the company's public CNG pumps."[233]

American Natural Gas Power (ANGP) was created in 1991 and is jointly owned by Crown Services, Exploration Company of Lafayette, La., and United States Transmission Company of Houston. Crown Services, formerly Crown Plumbing, with a fleet of 100 vehicles in Houston, had previously considered switching their vehicles to natural gas in 1983 but decided not to make the switch when the price of gasoline declined. ANGP has opened two refueling facilities. The first facility was opened in July, 1991 for refueling their own dual-fuel vehicles but, unlike Entex's private facility, any private vehicle is allowed to refuel at this ANGP facility. In addition, ANGP installed a CNG pump at an existing Shell service station on the Gulf Freeway at Scarsdale. Shell has opened several stations nationwide to determine the marketability of CNG; however, a Shell representative indicated that Shell currently forecasts

[231]Feltus, Anne, "Compressed Natural Gas Debuts at the Corner Gas Station," *Houston Business Journal*, November 2, 1992, p. 33.

[232]Feltus, 1992, p. 34.

[233]Feltus, 1992, p. 34.

that reformulated gasoline will be the "fuel of choice of the future." ANGP's current plans call for opening six to seven CNG service stations in Houston.[234]

Forecasts of Use of Alternate Fuels

Research conducted at the U.S. Department of Energy has produced several scenarios for future use of alternate fuels. However, this research emphasizes the infrastructure investment requirements and air pollution effects for use of different alternate fuels and do not provide forecasts of fuel use. The literature review did not locate any forecasts of alternate fuel use in Texas over the next 10 to 20 years. [At recent conferences in Texas, experts have mentioned various possibilities. One expert roughly forecasted that up to two or three percent would probably be the maximum extent of alternate fuel use in the next several years (say, in five to seven years) with ten percent being the <u>maximum</u> over the next 10 to 20 years. Another expert forecasted that up to one million vehicles might be using alternate fuels in Texas by the year 2000.][235]

Taxation Policies

Texas House Bill 1814 was passed by the 72nd Legislature, Regular Session, and became effective on June 16, 1991. This law established taxation of CNG used as a motor fuel. Prior to passage at that time, the law was vague with resultant lax and inconsistent collection of motor fuel taxes on CNG. After passage of this law, the State Comptroller's Office is able to rigidly enforce taxation of CNG in accordance with the statutes that apply to LPG or liquified petroleum gas (as the taxes are given in weight-mileage tables for LPG taxation).[236]

It appears that most of the fleet vehicles that use CNG will be refueling at existing public service stations or similar, new stations, even though some will be refueling at private CNG refueling facilities such as the one used by Entex vehicles in Houston that was discussed previously. Therefore, it may be possible to tax the fuel used by these vehicles in much the same way that gasoline and diesel are currently taxed. Based on efficiency considerations, these alternate fuels should be taxed at a rate such that similar vehicles are taxed about the same amount per mile of travel. Studies of the relative fuel efficiencies of typical vehicles can be used for setting the relative tax rates for the alternate fuels. In addition, legislation is needed to establish these tax rates. (Since use of alternate fuels is mandated by law to promote clean air, the argument that lower taxes are needed on natural gas for incentive purposes is not relevant.) It appears that the principal alternate fuels that will be difficult to tax are electricity used in battery-powered electric vehicles and hydrogen/fuel cell vehicles, and perhaps some LNG, CNG, methanol, and ethanol where the vehicles are not refueled at a public station.

The growth in use of alternate fuels in the next 10 to 20 years will depend mainly upon what types of reformulated gasoline the petroleum companies develop; the changing technology for engines, especially engines for CNG and LNG; the relative prices of gasoline and natural gas; how existing and new legislation are used to promote environmental and energy goals; and how the Clean Air Act is implemented.

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[234]Feltus, 1992, pp. 33-34, 36.

[235]Zane Goff, Personal Interview, Texas Transportation Institute, October, 1992.

[236]Griebel, Tom, "Fuels and Fuels Taxation," TxDOT Memorandum, October, 1991.