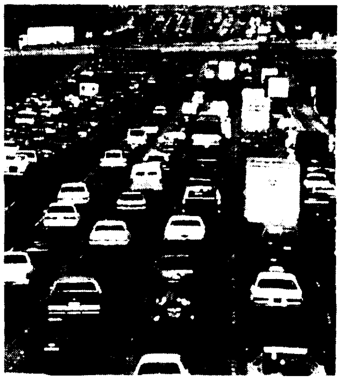
Why Intervene? Externalities, Unpriced Inputs, Problems Needing Solutions

4

In a "pure" free market economy, decisions about resource use and conservation are left to market forces, with resource price being the signal that guides production and consumption decisions. In the transportation sector, for example, oil price is a critical determinant of the number and type of trips that consumers make and the efficiency of vehicles that automakers produce and consumers buy.

WHY GOVERNMENTS MIGHT WANT TO ACTIVELY PROMOTE ENERGY CONSERVATION IN TRANSPORTATION

However, a completely free market economy does not exist in transportation. Instead, governments throughout the world intervene—and intervene strongly—in consumer and manufacturer decisions about the use of oil in transportation. Generally, governments throughout the world have chosen to control provision of the basic infrastructure for transportation—roads, bridges, tunnels, airports, and so forth. Although some basic infrastructure is allowed to be private (some airports, occasional private toll roads, and some railroads), this is more the exception than the rule. In addition, governments intervene directly in transportation markets. For example, some governments have chosen to restrict the purchase of private automobiles, generally because they consider their countries too poor to afford to import gasoline. With the notable exception of the United States, most countries in the Organization for Economic Cooperation and Development (OECD)—which includes Western European nations, Japan, Australia, New Zealand, Canada, and the United States—have



chosen to levy high taxes on gasoline, raising its price to several times the "free market" price. ' In the United States, government intervention in transportation oil use includes:

1. moderate fuel taxes, primarily to finance road construction and capital subsidies of transit systems;
2. fuel economy standards for automobiles;
3. disincentives to auto use (including parking restrictions, high-occupancy vehicle lanes, etc.) in State air quality implementation plans; and
4. operating subsidies for public transit.

U.S. government interventions are defended on a number of grounds. First and most widely accepted is the argument that some interventions (e.g., taxes on gasoline, which fund roadway construction) merely constitute user charges. Other grounds for existing and possibly increased intervention include:

1. correction for existing subsidies and pricing, and
2. external costs.

Correction for an Existing Network of Subsidies and Inefficient Pricing

Government intervention in the current market may be promoted as a correction to a web of past and ongoing subsidies and inefficient pricing mechanisms that have distorted the U.S. transportation market. Both public and private travel are subsidized. For example, on a percentage basis, U.S. operating subsidies for transit are among the highest in the developed nations at about 57 percent,[2] and capital subsidies for some systems are 100 percent. The United States also provides direct subsidies to private automobiles through payments for some roadway capital construction and maintenance from general funds, tax treatment of parking expenses that promotes free or low-cost parking for many workers and shoppers, and other means. In addition, some analysts claim that the Federal tax exemption for mortgage interest promotes low-density development patterns that favor private vehicles over public transit.[3] And U.S. tax policy creates cross-subsidies between different modes; for example, automobiles and light trucks pay a large share of the costs of highway repair through fuel taxes, whereas heavy trucks cause most of the damage.[4]

Aside from subsidies, inefficient pricing also distorts transportation decisions. For example, retail establishments commonly absorb the price of parking into their business costs, rather than charging customers--even though the customers eventually "pay" through higher prices.[5] Consequently, the apparent cost of transportation is reduced, encouraging more tripmaking than if travelers had to account for the full costs of their travel.

Externalities

Intervention may also be justified by the argument that transportation users are imposing costs on others that they do not consider in their travel decisions, and therefore travel more than is optimal for society. Theoretically, if these external costs ("ex-

[1] OECD tax policy on gasoline and vehicles appears to be primarily a matter of governments viewing these products as an excellent source of revenue for a broad range of societal functions, with a desire to restrain oil use and traffic congestion also a factor.

[2] American Public Transit Association, *1990 Transit Fact Book* (Washington, DC: September 1990).

[3] Note however, that the mortgage interest deduction applies to all residential properties, including rentals (lowering costs for owners, allowing lower rents). It "promotes" lower density development (rely to the extent that by lowering costs of housing generally, it allows a greater choice of housing to the average citizen; the km-density option must be preferred for it to be promoted by greater choice.

[4] U.S. Congress, Congressional Budget Office, *Paying for Highways, Airways, and Waterways: How Can Users Be Charged?* (Washington, DC: May 1992).

[5] paradoxically, prices at large suburban stores with free parking may be lower than at urban stores that require no special parking facilities, because of the economies of scale and wide market reach of the suburban stores, As discussed in the following section, this is a benefit of auto-oriented travel not often considered in evaluating the social cost pricing of travel.

ternalities") could be added to the price of travel, travelers would make more economically efficient choices.

Some analysts define externalities as costs that are caused by a *class* of activity, such as all motor vehicle travel or all auto travel, and imposed on everybody else or on society as a whole. This is useful in examining the costs and benefits of motor vehicle or auto travel, but it is too narrow a definition if the concern is whether such travel is overused because drivers are not accounting for the costs they impose on others. For the latter concern, externalities also include costs that individual drivers impose on others and do not account for, *even if the others are also drivers.* **Thus,** drivers deciding to travel during peak periods may recognize clearly the congestion costs they incur, but they do not take account of the costs they impose on other drivers. Were they forced to, some might choose to drive lessor to drive at nonpeak periods. Some critical transportation externalities are:

1. *Environmental and safety impacts.* Federal requirements for emission controls on new automobiles, inspection and maintenance requirements on the entire fleet, and other pollution control measures have reduced the potential air pollution impacts of oil use in transportation. There remain, however, substantial environmental impacts whose costs are not included in the price of gasoline and diesel fuel, in vehicle prices, or elsewhere in the market price of transportation. These impacts stem from remaining air emissions, including emissions of carbon dioxide and other "greenhouse" gases, as well as from oil leaks and spills, sprawling patterns of development associated with auto dependence, and other sources. The existence of these externalities and others, such as vibration damage to roadside structures and safety risks to pedestrians, implies that oil consumers do not pay the full societal cost of their oil use and thus consume too much—potentially justifying governmental action to raise oil prices or otherwise reduce consumption.
2. *Energy and economic security.* A substantial portion of the world's oil production and export occurs in unstable areas and is managed (though with intermittent success) by a cartel-like organization, and the U.S. transportation system combines near-total dependence on oil with an inability to rapidly substitute alternative fuels. U.S. dependence on imports for half of its oil supply therefore creates a risk to the U.S. economy from supply disruptions. Current oil prices do not include the cost of U.S. military expenditures to protect the oil supply in politically unstable areas or other security costs. To the extent that energy security would improve (and security costs decrease) if U.S. oil imports declined, government measures to reduce consumption (and increase domestic supply) can be justified. However, an important caveat is that any effect of oil use reductions on energy security will be highly nonlinear--small reductions are unlikely to have any effect on energy security. As a result, charging a premium on oil prices for energy security effects will yield the desired decrease in security costs only if oil use is reduced enough to make a real difference in U.S. energy security and military strategy.

   Another societal effect of U.S. transportation dependence on petroleum-not a true security effect—is the extent to which this oil use affects world oil prices. A large drop in U.S. oil consumption would lower world oil prices, yielding a strong benefit to the U.S. economy and to individual consumers, but this effect is not considered in individual oil use decisions.
3. *Congestion.* As noted above, congestion costs can be considered an externality to the extent that drivers during congested periods impose costs on all other drivers sharing the road but do not account for these costs in their decisions to drive. Congestion also adds to environmental and energy security external costs, because stop-and-go driving both wastes fuel and generates more pollution per mile than free-flowing driving.

Society's beliefs about these problems and externalities. and policy makers' understanding of them, are critical to formulating and initiating successful policy intervention in the transportation system. Unless there is a strong consensus that the problems faced by the U.S. transportation system are truly critical and *must be* solved, and that externalities and inefficient pricing will prevent the market from solving them, the U.S. public is unlikely to support much additional intervention—because the transportation system is so crucial to quality of life, and because many proposed policy interventions seek significant changes (either in cost or in system structure) in an automobile-oriented system that is firmly entrenched in American society. Further, selecting optimal intervention mechanisms is unlikely unless policy makers understand the complex and varied interactions between different policy instruments and the full range of problems and externalities.

Policy makers must recognize also that the automobile may offer society external *benefits* that ought to be considered in any attempt to adjust the market. The economies of scale achieved by auto-oriented superstores, the social integration and mobility offered by widespread automobile availability, and the special mobility offered in rural areas all have societal benefits (and perhaps costs) as well as private benefits. Unfortunately, there is little understanding of such potential benefits of the private automobile; as a result, attempts to evaluate and redress problems with auto externalities have tended to focus exclusively on costs.

Finally, policy makers who wish to "correct" the amount of transportation demanded by travelers and shippers by accounting for inefficient pricing, subsidies, and externalities should remember that the other "goods" in consumers' market baskets—housing, food, entertainment, education, and so forth-do not operate in a free market environment either and, to differing degrees, share the transportation sector's pricing and subsidy distortions and also generate externalities. It maybe that *all* forms of consumption are somewhat underpriced in the U.S. economic system. Correcting transportation prices—presumably by raising them, if transportation's combination of external costs, subsidies, and inefficient pricing mechanisms outweighs any external benefits-should improve the efficiency of the allocation of transportation demand among competing modes and move *overall* transportation demand closer to an economically efficient level. Failure to correct pricing in the other sectors may, however, compromise some of the efficiency gains that would otherwise flow from correcting transport pricing.

This chapter describes and evaluates the various externalities, pricing inefficiencies, and embedded subsidies that distort the market for transportation energy. It also--qualitatively and tentatively-describes some potential benefits of today's auto-dominated system. Analysis of these issues is relatively new, data are scarce, and there is no consensus in the scientific community about the magnitude of transportation externalities and subsidies. In spite of this lack of consensus, however, the United States has spent many billions of dollars in subsidies to various transportation systems and is preparing to spend many additional billions of dollars during the next few decades, based on the supposition that free market forces will not by themselves create a satisfactory transportation system. It seems obvious that a better understanding of the externalities, inefficient pricing systems, and embedded subsidies would be valuable to the process of designing U.S. transportation policy.

AUTO BENEFITS

Critics of the U.S. automobile-dominated transportation system generally try to explain the strong preference for autos as a natural response to a system of skewed incentives—government subsidies of many auto costs, widespread provision of free parking (and government tax policy that rewards such provision), failure to incorporate "external" costs (air pollution, noise, etc.) into fuel prices, and land use policies and tax incentives that favor single-family home ownership and low-density development. Some cite additional causes such as the alleged auto and oil industry sabotage of public transportation systems and relentless advertising of the joys of auto ownership.

These forces no doubt do play an important role in the strong dominance of automobiles in the

U.S. transportation system, but they do not constitute the whole story. Many of the incentives probably should be viewed not only as causes of U.S. auto orientation but also as *results* of it: they are a natural response of voters and voter-responsive legislatures to the public's desire to accommodate an automobile-oriented system. More important, the European example. discussed in chapter 3, demonstrates that the combination of an incentive system that taxes gasoline very highly (enough to incorporate at least a significant portion of external costs), a set of land use policies that favor-s urban over suburban development, and the nurturing of an extensive system of public transportation still does not prevent the automobile from becoming the dominant transportation mode. Something else besides monetary and land use incentives appears to be propelling the automobile's dominance of personal travel. In other words, automobile use clearly is perceived by many as having real benefits *other than those created by artificial incentives* in comparison to the use of alternative modes or to the option of not traveling. These benefits are primarily "internal" or private benefits that accrue directly to drivers and passengers (e.g., low door-to-door travel time, comfort, flexibility) and "external"' benefits that accrue to society as a whole or groups other than drivers (e.g., more locational options for owners of small businesses).

Many proposals for reducing transport energy use and environmental damage involve reducing the automobile's share of personal travel or reducing the total volume of travel. Effective strategies cannot be devised, however, without understanding the nature of the attachment that Americans have to their cars. Such understanding might help identify ways to weaken the attachment in the future. Further, understanding the broader societal benefits of automobile use is essential for policymakers who wish to incorporate full social costs and benefits into transportation decisionmaking, perhaps by folding these costs and benefits into the market price of travel (through charges on gasoline, vehicles, vehicle-miles traveled, or other measures). This section discusses available research about U.S. attitudes toward automobiles and the private benefits associated with the automobile orientation of the U.S. transportation system. Unfortunately, our understanding of the external benefits of automobile use is extremely weak, because judgments about the value of the factors that generate these benefits—such as differences in urban structure and retail store location and character —are highly subjective in nature.

Attitudes Toward Automobiles

Research by J.D. Power and Associates can help illuminate the character of Americans attachment to their automobiles. In its survey research, Power has determined that U.S. car drivers can be broken down into six attitudinal groups (their shares of all drivers are in parentheses):

1. functionalists, who want sensible, fuel-efficient transportation (11.8 percent);
2. gearheads, who are car lovers and true enthusiasts (16.7 percent);
3. negatives, who view cars as necessary evils that they would love to do without (15.8 percent);
4. epicures, who want stylish, elegant automobiles (25.9 percent);
5. purists, who like cars but are very skeptical of all claims (4.2 percent); and
6. road haters, who are fearful of anything but normal driving (25.5 percent).[6]

An interesting conclusion from this list is that if functionalists are included, 53.1 percent of drivers (functionalists, negatives, and road haters) appear to be amenable to giving up their vehicles or greatly reducing their driving if a viable alternative is offered. Of course, the important question left unanswered by this survey is, what constitutes a viable alternative for those who are not attached to their autos. The perceived advantages of automobiles—such as virtually door-to-door service, generally shorter travel times, privacy. and com-

[6] J.D. Power and Associates, "Finding Customers May Be Just a Matter of Attitudes," *The Power Report*, newsletter, June 1991.

fort—present a formidable challenge to potential alternatives unless auto users begin to perceive important disadvantages in the use of their vehicles.

"Internal" or Private Benefits

Autos are the overwhelming choice of short-distance travelers in the United States because of a number of advantages over their transit competition. In particular, automobiles generally provide faster service than mass transit, primarily because they offer virtually door-to-door service, whereas transit requires multiple links. A typical auto-based trip involves a short access walk, no waiting to transfer to the auto, a relatively direct trip, and a short access walk at one's destination. In contrast, atypical transit-based trip may involve a significant walk or drive to reach a bus stop or train station; a wait of at least a few minutes; quite often, more than one transit trip interspersed with waiting periods (and the total transit phase may include two or more transit modes); and a walk or drive to reach the destination. When transfers are involved, the transit route is quite often more circuitous than an auto route (although a rapid rail route occasionally will be less circuitous than a highway route).

In addition to time savings, autos generally offer better protection from the elements, greater comfort (especially during peak periods when transit seats are at a premium), and greater protection from crime (although certainly not better overall safety). Autos also offer freight-carrying capacity, which allows consolidation of shopping trips that would be difficult or impossible by mass transit as well as access to stores that, by combining many services into one location, allow great time savings (especially for the frequent chore of food shopping). Further, automobiles offer travel flexibility (in terms of choice of time of day and destination) that would be extremely difficult to obtain in a transit-oriented system, thus expanding the universe of social, cultural, and recreational opportunities.

Automobiles also offer longer-distance family travel, especially for larger families, that is less expensive than public transportation and far more flexible in choice of destination, time of travel, and ability to change routes and destinations.

An automobile-oriented transportation system allows low-density residential development patterns that are often criticized as wasteful of land, inefficient in their use of energy, and sterile in their access to cultural opportunities and their segregation by economic class. However, the residents of these developments, who must be heavy users of the automobile system, may reap substantial benefits from these patterns. Cul-de-sac development may guarantee inaccessibility to efficient transit services and inefficient road use when measured simply as the length of road needed to provide access to services, but it offers a low-speed and lightly traveled environment in the immediate area. Moreover, although separation of commercial and residential development demands longer trips and the use of automobiles, whereas mixed development could allow walking and bicycling as substitutes, it also avoids the traffic concentration and aesthetic intrusion that commercial development may make on residential areas. Although there may be a heavy price to pay for these amenities, policy makers cannot ignore the reality that they are highly valued.

Benefits to Society

Automobile use has created many problems for modern society, and these problems form the core subject of attempts to understand and measure auto "externalities." It is unlikely, however, that the type of mobility the automobile offers, and the land use patterns that heavy reliance on autos tends to engender, yield only costs to society, Although the American "love affair" with the auto is now generally the subject of derision, use of the

[7] Food shopping still consumes a great deal of time in some industrialized countries where the retail network consists mainly of small specialty shops.

automobile offers benefits to society that must be considered in any “full cost accounting” that seeks (o fold the external effects of a technology (environmental, social, etc.) into its market costs. The brief discussion that follows is not meant to extol the virtues of the automobile, but instead to suggest that as a transportation tool, the automobile "ain’t all bad. ”

Many of the external costs of automobiles, although sometimes hard to measure quantitatively, are quite easy to describe and understand qualitatively—air pollution and its health, ecosystem, and material impacts; noise pollution; land use preemption; and so forth. Benefits tend to be more subjective. For example, the ready availability of automobiles, and of an extensive road and parking network, allows remarkable travel flexibility at any time of day or night. Perhaps a transit-oriented system could approach this flexibility by combining fixed route transit with demand-based service available in nonpeak hours, but this has not been demonstrated. Such flexibility allows a degree of spontaneity in tripmaking that is a strong private benefit but must also be of value to society. Further, increased access to a range of cultural, recreational, and educational opportunities represents both a private (as noted above) and a public benefit: the social and economic integration promoted by this access.

The retail shopping and service base that develops in an automobile-oriented system is different from what would develop in a transit-oriented one. So-called superstores that attain considerable economic benefits from their large scale—and pass these benefits on to customers-cannot exist unless they can draw from a wide geographic area.[8] Further, these stores depend on shoppers who can make a shopping trip a major purchasing expedition, which would be impractical without private “freight transport” home, especially for larger items, Such superstores would be much less feasible with a transit-oriented transportation system. Their economic efficiency benefits society, although the existence of these stores may influence factors other than efficiency, such as the general availability of a diversity of products and services, that also bear on their net value to society.

The move to an automobile-dominated transportation system has been synonymous with a societal movement away from the home (and family) as the focus of social interaction. The extent to which the auto has been the major cause, partial contributor/enabler, or innocent bystander to this movement is unclear, but it seems likely to have played a significant role. It is normal in our society, for example, for both children and adults to use evenings for education, exercise at clubs, and numerous other activities outside the home that would be more difficult without auto mobility, even with the higher density of a transit-based area (given the reality of urban safety, how many children would be allowed to visit friends at night if mass transit, walking, and a wait at a bus stop were necessary?). Whether the movement from the home as center of social interaction should be viewed as a cost or benefit to society is a philosophical question, but it is clear that some will consider it a positive contribution to personal growth and social integration and well-being, whereas others will feel it has had a strong negative influence on family values.

Automobile transportation provides special benefits in rural areas, where mass transit services are impractical. It allows social interaction that would be impossible without private transport and (coupled with truck freight services) enables the employment in light industry that has allowed large numbers of Americans to live outside cities, despite the vast decline in agricultural employment.

Note that the major differences in mobility between auto- and transit-dominated systems undoubtedly occur during off-peak times, when transit cannot maintain high-frequency service *and*

[8] Although higher residential densities associated with a transit-oriented area allow more customers to be available to a store within a set radius or area, this is unlikely to compensate for the market afforded by an auto-oriented suburban location.

the time advantage of autos becomes particularly large. Aside from the expansion of nighttime nonwork activities engendered by the temporal flexibility of an auto-oriented system, flexibility in work schedules has been promoted: second and third shifts may be more practical in such a system. This has both private and social benefits: private in terms of obtaining employment that better fits people's schedules, and public in terms of increased economic productivity. It also has costs: not all employees take second- or third-shift jobs voluntarily, and the ability to schedule multiple shifts might alter the balance of jobs away from daytime and toward nighttime in ways that could be efficient for employers but destructive for private and societal values.

Critics of the automobile tend to portray the low-density land use patterns that have accompanied automobile growth as uniformly negative in terms of their public impacts: in other words, they argue that suburban or exurban development occurs only because it yields some direct benefits to those who live there, and that this type of land use exacts high costs from society in general. The idea that these land uses are a legitimate alternative, that society may benefit from the availability of suburbs as one option available among choices of lifestyle, is rejected. Instead, suburban development is regarded by its critics as a despoiler of urban life and a primary cause of the inner-city decay and loss of tax base affecting so many U.S. cities.

There obviously is much that is subjective in such an evaluation. Although low-density, suburban development clearly has important negative environmental and social impacts, it is worth asking whether limiting future development to higher densities will really yield large benefits. The answer undoubtedly lies in the extent to which suburban development can be tied to the problems of today's cities. If this development is a cause of current urban problems, and if a radical shift to higher density development and strict limits on suburban growth would clearly improve central-city life, then perhaps the critics are right and suburbs offer no benefits to society other than those reaped by their inhabitants. If the current problems of the cities have other causes, however—if suburban development is not really the proximate cause—then the availability of a low-density option increases the diversity of choice and provides benefits to society, which then must be balanced against the costs.[9]

INEFFICIENT PRICING: SUBSIDIES, EXTERNALITIES, HIDDEN COSTS

How does one go about evaluating the magnitude of subsidies, hidden costs, and external costs associated with transportation? This section presents a framework for examining these costs and a series of estimates for most categories of costs.

Introduction and Viewpoint

A number of studies have attempted to estimate the "total costs" or "full social costs" of motor vehicle travel or of transportation in general, in order to explore the extent to which drivers may fail to pay such costs and, in response, "consume" too much travel. Most of these studies conclude that motor vehicle travel is substantially underpriced in the sense that drivers are paying considerably less than the total costs of their driving:

> Commuters going to work in major central business districts in the United States in their own motor vehicles directly pay for only about 25 percent of the total cost of their transport. The other 75 percent is typically borne by their employers (e.g., in providing "free" parking), by other users (in increased congestion, reduced safety, etc.), by fellow workers or residents (in air or noise 'pollution," etc.) and by governments (passed on to the taxpayers of one genera-

[9] An extreme negative view of suburban development is not, of course, the only point-of-view expressed by advocates of denser land uses. Many would instead claim that suburban sprawl is, in many areas, the *only* option open to new home purchasers rather than an option that increases housing diversity. In regions where this may be the case, "densification" of land use would add to options by adding a middle ground of medium density development, as well as strengthening the urban core by infill development.

tion or another in ways that usually bear no relationship to auto use). '"

However, these studies use a variety of accounting systems to identify unpaid costs, and it is difficult to compare their results.

The Office of Technology Assessment (OTA) asked Mark DeLuchi of the Institute of Transportation Studies, University of California at Davis, to evaluate the social costs of motor vehicle use *and how they are paid,* focusing particularly on those costs that have market prices or, if unpriced (e.g., free parking at shopping malls), that can be priced by comparing them to similar priced costs.[11] Although part of the reason for the automobile's dominance of U.S. transportation results from past subsidies, this study focuses on 1990 costs, since new policy initiatives must take the current transportation infrastructure as a starting point.

Evaluating the full social costs of motor vehicle travel is a relatively new and contentious field of analysis. DeLuchi's work, which follows and builds on earlier studies, will not be the last word on this issue. Further, several of the cost areas, for example, potential damages from global warming and national security costs, remain highly uncertain. Thus, OTA presents DeLuchi's work as a valuable contribution to the field, but does not endorse the specific values in each cost category. On the other hand, we believe the work to be sufficiently robust to endorse DeLuchi conclusion that a significant fraction of social costs is not efficiently paid by motor vehicle users. Inclusion of these costs into motor vehicle charges, and restructuring of payments so that those who incur the costs take them fully into account in their travel decisions, would likely reduce the total amount of motor vehicle travel and shift some of it to other times or locations.

There are, of course, other, competing evaluations of both the total social costs and specific external costs of transportation. Some of these evaluations, e.g., those of the Congressional Research Service, are discussed briefly in the other sections of this chapter. A variety of studies are discussed by Hanson.[12] OTA will soon publish a study reviewing different estimates of the environmental externalities of electricity generation.

The definition of a particular cost of driving as paid or unpaid, or as efficiently or inefficiently priced, has much to do with the *purpose* of the accounting. Analysts concerned primarily with ensuring that automobile users pay for the costs of auto use, to avoid subsidizing automobiles, focus their analysis on whether auto users *as a class* pay their full costs. For example, although congestion causes some societal costs (more pollution, lost productivity), its primary cost is lost time, and this is borne primarily by the drivers and passengers on congested roads (although it also impacts freight costs). Thus, in terms of equity among such alternative travel modes as auto, rail, and air, road congestion is largely an internal cost of auto travel. In contrast, when police services on highways are paid out of a community's general funds while the rail transit system pays for transit police and charges a higher fare as a result, auto users receive an inequitable subsidy.[13]

In terms of economic efficiency, to ensure that a good is not under-or overconsumed, it is more important to worry about an individual decisionmaker (i.e., potential purchaser), not a class; *what matters is whether or not individual decisionmakers recognize and pay an appropriate price for what*

[10] E.W. Johnson, "Taming the Car and Its User: Should We Do Both?" *Aspen Quarterly,* autumn 1992, based on a presentation by J. Meyer, Harvard University.

[11] DeLuchi's report will be available separately, but the key results are summarized here.

[12] M E. Hanson, "Results of Literature Survey and Summary of Findings. The Nature and Magnitude of Social Costs of Urban Roadway Use," paper prepared for U.S. Department of Transportation, Federal Highway Administration, 1992.

[13] To complicate this issue further, however, rail transit systems obtain much of their revenues from public funds.

they receive. In the case of congestion, each new driver who enters a busy road is delayed and thus pays a price in lost time, but also inflicts costs on drivers already on the road, costs that the new driver does not bear.[14] That new driver is paying *average* costs rather than marginal costs. This is very similar to new customers on an intensively used electrical grid that must add expensive new capacity to accommodate them; although the new capacity may be more expensive than the older part of the system, thus raising costs for all users, new users make their decision to use electricity by accounting only for a fraction of the additional costs that they create.[15] In other words, the "appropriate price" from an efficiency standpoint is *marginal* cost, not average cost.

Aside from paying the wrong price (e.g., equal to average rather than marginal costs),[16] auto users may not recognize the price they are paying because it is hidden. Free parking at shopping malls is not really "free" because its costs are included in the price of goods at the mall. Thus, drivers may pay much of the cost of this parking, but they are unlikely to take account of it in deciding whether to visit the mall. Free parking for shopping is also an example of a societal subsidy of automobile travel, because everybody who shops at the malls bears part of the parking costs even if they walk or use transit.

Also, individual auto users may not be paying the right price because they create nonmarket costs that they do not fully bear: air pollution, global warming, loss of energy security through their oil use, pain and suffering inflicted on others from accidents, and congestion delay costs. These are the so-called externalities--nonmonetary damages inflicted by auto users on others and not considered in driving decisions.

In summary, to ensure efficient use, individual drivers must pay and account for the marginal costs to society that they create when they choose to drive. Problems arise when others—including other drivers—pay these costs; when drivers pay the costs but not in a way that they recognize and account for in their decisionmaking; when the price is not the marginal price, so drivers do not realize the full impact of their decision; or when those who pay the costs cannot choose the amount of good or service that they pay for and consume.

Table 4-1 provides a classification of the different costs of motor vehicle use, according to basic cost categories, whether (or not) they are monetary costs, whether they are paid for by those who cause them, and so forth. In essence, the classification scheme focuses on whether, or to what extent, an item is efficiently priced at the marginal social cost of supply. The sum of all of the costs in table 4-1 represents the social cost, or total resource (welfare) cost, of motor vehicle use. Another way to put this is that the social cost of motor vehicle use is *what would not have been incurred had there been no motor vehicle use.* Only the costs in the first column of the table are efficiently priced; all others are priced either inefficiently, indirectly, or not at all.

The logic behind this classification scheme, or behind any other, does not work well with every type of cost, and users of this analysis will argue with the placement of some costs, For example, there is room for argument about the extent to which motor vehicle users actually account for some costs (e.g., their probability of getting into an accident and being injured or killed) in their travel decisions. Also, because some types of costs have components that are paid by users and other components paid by nonusers (or efficient] y

[14] In this sense traffic congestion is an externality, at least from the standpoint of the individual driver,

[15] This problem has become less common than it was, because pollution controls have raised the cost of electricity from many older powerplants. and new capacity using natural gas is relatively inexpensive.

[16] in the case of congestion costs. Prices of other travel goods and services may be wrong because they are poorly related to marginal costs in some other manner (e. g., the price may be subsidized).

TABLE 4-1: Classification of the Costs of Motor Vehicle (MV) Use

Efficiently allocated	**Not efficiently allocated**				**Efficiently allocated**
Items accounted for by users in MV ownership and use decisions	Items *not* accounted for by users in MV ownership and use decisions				Items accounted for by users in MV ownership and use decisions
Efficiently priced items each user and no nonuser is charged, and price probably equals marginal cost	Inefficiently priced items each user and no nonuser is charged but price probably does not equal marginal cost	Implicitly, inefficiently or Indirectly priced items nonusers as well as users pay, and the MV cost is buried in tax or price of other commodities		Unpriced items	Price is r70t relevant, because there is no transaction (but marginal value = marginal cost)
■ Those who pay for these items choose the amount that they pay for and consume ■ If you do not own and use MVs, you do not pay these MV costs ■ The party responsible for the cost always pays all of it		■ Those who pay for these items cannot (or can but do not) choose the amount of the item that they pay for and consume ● Even if you don t own and use MVs, you still might pay these costs ■ The party responsible for the cost often pays l ittle or none of It			● Accounted for and borne entirely by MV users
Monetary costs				**Nonmonetary costs[a]**	
1 *Motor vehicles, fuel, parts, and service, excluding taxes and fees* Usually included in estimates of the cost of owning and operating MVs ■ New and used MVs (excluding sales taxes and charges on producers) ■ Interest payments for MVs ■ Fuel and oil (excluding taxes and fees) ■ Maintenance, repair, washing, renting storage, towing ■ Parts, tires, tubes, accessories ■ Automobile Insurance ● Parki ng away from home (excluding parking tax) Usually not included ■ Vehicle safety and smog inspection [c] ■ Accident costs paid for by responsible party but not covered by auto insurance lost productivity,[d] medical, legal, property damage[e]	2 *Public Infrastructure and services covered by the following use charges (see column 4 for list of costs)* Usually Included m estimates of the cost of owning and operating MVs ■ FHWA-classified road-user taxes and fees fuel taxes, road tolls [h]commercial road-user fees vehicle registration fees, driver's license fees (excludes fees dedicated for nonhighway purposes) ■ Portlons of fuel tax dedicated to nonhighway purposes ■ Investment income from the Highway Trust Fund ■ Charges levied on producers and included in selling price of goods (e g , for vehicle certification tests, Superfund cleanup, and oilspill cleanup) ■ Sales taxes [i]	3 *"Hidden" private-sector costs* Unpriced parking [j] Local roads provided or paid for by the private sector, and Included in the price of structures or services ■ Accident costs[k] paid for by those not responsible and not covered by any auto Insurance lost productivity,[d] medical, legal, property damage[e] ● Monopsony price effects of using 011	4 *Public infrastructure and services, not fully covered by charges m co/-umns 1 or 2* ■ Highway construction, maintenance administration ■ Pollee protection ■ Fire protection ■ Judicial and legal services ■ Correctional system ■ Environmental regulation and protection ■ Energy and technology research and development ● Military defense of oil supplies ■ Strategic Petroleum Reserve ● Payment of costs of accidents lost product w-ity medical, legal, property damage [e] ● Other social services ■ Free or underpriced municipal parking ■ Differential tax treatment of energy producers (tax subsidies or penalties)	5 *"Classical" externalities* ● Air pollution ■ Global warming ● Water pol lution ■ Solid waste ■ Noise and vibration inflicted on others ■ Social and aesthetic impacts ■ 011-price shocks ■ Traffic congestion inflicted on others ● Pain and suffering and deaths inflicted on others from accidents [m]	6 *Personal nonmarket costs of using MVs[b]* ■ Travel time (excluding delay Imposed by others, column 5) ■ Personal time spent working on vehicles and garages ■ Privacy, comfort, convenience, safety while driving (combine with travel time to make general attribute activities foregone while driving) ■ Pam and suffering and death from accidents (excluding that inflicted by others, column 5) ■ Noise and vibration (excluding that inflicted by others, column 5)

• Home garages and other residential parking.[f,g]	Usually not included: • Air-quality fees (paid with registration). ▪ In-1ieu property taxes (paid with registration) • Traffic fines. • Parking fines, ▪ Parking taxes,					

a Note that an externality is not defined as any nonmonetary (or nonmarket) damage, rather, an externality is one kind of nonmonetarydamage All nonmonetarydamages can be classified into three mutually exclusive and exhaustive categories relevant to policymaking First are externalities; those damages (air pollution, global warming, pain and suffering, etc) Inflicted by motor vehicle user A on party B and not accounted for byA These are the "classical" externalities of this table, and as indicated in table 5-9 the prescription for them is a dynamic Pigouvian tax on the perpetrator with no direct compensation of the victim The second category is those damages inflicted by motor vehicle user A on party B but accounted for by A as marginal cost of motor vehicle use These are appropriately internalized nonmoney damages, when an externally is properly taxed, it becomes this second type of damage (internalized) If there were any such internalized (formerly nonmonetized) damages, theywould be classified as user payments in columns 1 or2. However, the United States does not levy any "externality adders" or internalization taxes for nonmonetary damages of motor vehicle use (Note that in adding up the social cost, one would count either the internalization charge or the actual damage estimate-they represent the same thing-not both.). The third category is self -inflicted damages or costs by a motor vehicle user, for example, the nsk of hurting oneself in an accident of one's own causing These are the "personal" nonmonetized costs of column 6

b Personal costs—travel time, comfort, safety, and privacy while driving (activities foregone while driving), the nsk of pain and suffering and death, and pollution and noise (excluding those costs imposed by others) are included because they are considered "costs" in lay terms However, if one categorized these items in strict economic terms, with respect to supply and demand curves, then they most naturally are demand-side (use-value) rather than supply-side items, and therefore economic "benefits" rather than costs In any event, the notion of price, or efficient market allocation of resources, is not relevant, because these items are not exchanged, or traded in markets, they are "Imposed" by users directly on themselves The only economically relevant concern is that each user accurately assess these self-generated costs to himself Note that these same sorts of costs imposed on others do Involve interactions; they are externalities (if unaccounted for) and theoretically should be priced or taxed Externalities are included in column 5

c Includes only those payments made for inspections at privately run stations, not payments for government-administered programs, because the latter presumably are included in the Federal Highway Administration's reported receipts from imposts on highway users (column 2) Privately run inspection programs presumably charge marginal costs, whereas government programs may not

d Lost productivity can be disaggregated into the portion that the individual keeps (net wages) and the portion that the government keeps as income taxes. This seems like a conceptually unnecessary complication: the loss is the total productivity of the individual; the disposition of the income is (usually assumed to be) Irrelevant in a cost-benefit analysis

e Excludes the cost of repairing and replacing vehicles or roads because all of those costs, whether caused by accidents or not, are classified as expenditures on vehicles (column 1) or highways (columns 2 and 4) It therefore includes only the relatively small amount of damage to other property, such as buildings It is worth noting, though, that if in deciding whether to buy or use motor vehicles, people consistently underestimate their probable out-of-pocket payments (those not covered by Insurance) for repairing or replacing accident damage to their own or others' vehicles, then they will use motor vehicles more than is socially efficient (i e , more than they would if they possessed and acted on the right reformation)

f It is questionable whether these costs really are accounted for fully by motor vehicle users when they make motor vehicle ownership and use decisions

g Includes interest payments on the garage portion of the total *cost*

h Some road tolls, perhaps by coincidence, may be priced efficiently Similarly, some frees and producer charges may be efficient (set equal to marginal cost), probably by coincidence

i All but a small fraction of this probably should not be counted as a payment by motor vehicle users for motor vehicle use

j The text discusses the important differences between garages and unpnced parking

k Costs that the affected party (who is not at fault) pays out of pocket or through private Insurance other than auto Insurance Costs covered by the automobile insurance of the affected party (who is not at fault) are included under "automobile Insurance" in column 1 (All auto Insurance costs are in column 1, even though some of the costs covered by auto Insurance are attributable to accidents caused by others, because the relevant cost is not the cost of the items or services covered by Insurance but the cost of the Insurance policy itself, and the cost of the Insurance policy is borne by and attributable to the person who buys it) Costs paid by the responsible party also are included in column 1, under either "automobile Insurance" or "accident costs " Costs paid by the government are included in column 4 of this table

l A pecuniary externality, a transfer between consumers and producers, and hence not normally a true economic cost or benefit But if a particular class of producers (e g , foreign 011 producers) is excluded from the welfare analysis, then consumers' loss is not balanced by producers and is thus a real net welfare loss within the scope of the analysis

m Includes pain and suffering inflicted on pedestrians, cyclists, and other nonusers of motor vehicles, as well as other users of motor vehicles This also should Include the cost of the threat of accidents to other drivers, pedestrians, and cyclists, but no data are available on this cost

SOURCE M A DeLuchi, University of California-Davis, 1994 allocated components and inefficiently allocated components), these costs must be divided in unusual ways to fit this classification scheme (e.g., accident costs appear in three separate places according to who is responsible for the accident and whether the costs are monetary or nonmonetary). However, there is substantial value in pursuing this classification scheme, rather than simply adding up costs according to their physical nature. because the policy prescriptions for dealing with each category are different. Thus, knowing the magnitude of the costs in each class is necessary to inform policy choices. Policy options for dealing with the various categories of inefficiently priced or unaccounted-for costs are discussed in chapter 5.

An issue that is not dealt with explicitly in the classification scheme outlined in table 4-l is that of time: to what extent should costs be classified as "fixed" or "variable," and what should the relationship be between policy measures and the time horizon of the costs? This issue is dealt with in slightly more detail at the end of this section, but ignoring the time horizon implies that one is viewing travel behavior over the long term, during which changes in vehicle costs can have as significant a role as changes in fuel cost; and trying to separate short-term (variable) from long-term (fixed) costs implies that one is viewing travel behavior in the short term and attempting to change behavior by altering the traveler's perception of costs faced on a daily or weekly basis.

Two last but critical points: first, the estimate of social cost derived here is only an average cost. This much would be saved if motor vehicle use were eliminated, and thus an average value of the reduction in vehicle-miles traveled (vmt) can be calculated by dividing social cost by total vmt. We cannot be sure, however, that the marginal cost of a small reduction (in dollars per mile) would be the same as the average cost, and for some cost components, we know it is not. Since viable policies seek only to reduce motor vehicle use by a significant but small fraction-a 10-percent reduction would be optimistic--the average rate calculated from this social cost estimation may not yield the correct estimate for such a small reduction. On the other hand, in at least some scenarios of relatively large changes in motor vehicle use, the average rate of social cost reduction might be a serviceable approximation of the actual marginal rate.

Second, although OTA has substantial confidence in the estimates of monetary costs, the estimates of the cost of externalities warrant less confidence. In some areas (e.g., the cost of global warming impacts associated with a unit volume of carbon dioxide emissions), extremely large uncertainties exist, and these estimates should be considered tentative. In other areas (e. g., the cost of air pollution damages), estimated values are firmer, although they are not without controversy.

Detailed Results

Monetary Payments for Motor Vehicles, Fuel, and Other Items

The largest part of the social cost of motor vehicle travel is the private cost of new and used cars and trucks, gasoline and oil, maintenance costs, and the variety of other costs ('parking, insurance, inspection costs, etc.) that maintains the rolling stock of motor vehicles, Wages of freight drivers constitute a special category of costs that must be included to incorporate highway freight transportation properly into the accounting system. Table 4-2 lists the private payments for these items, which account for more than $800 billion of the total social cost of motor vehicle travel. All of the items listed in the table are bought and sold in markets that function more or less properly. Consumers face and account for the price of each of these items, and the price (presumably) equals the marginal supply cost. Thus, the items in this category are produced and consumed efficiently. An interesting point is that the Federal gasoline tax used to construct highways, as well as road tolls and vehicle registration fees, are not included here because the taxes, tolls, and fees are only loosely tied to the infrastructure and service costs they are designed to pay for.

TABLE 4-2: National Payments for Motor Vehicles, Fuel, Parts, Service and Wages of Freight Drivers, 1990 (billions)

Item	Low cost	High cost	Weight on cost
Passenger vehicles			
New and used cars and trucks (including embedded fees levied on producers; these are deducted en masse below)	$2217	$2217	1
Interest on debt for new and used cars and trucks	437	437	
Gasoline and 011 (including road-user taxes and fees, these are deducted en masse below)	1240	1240	1
Maintenance, repair, cleaning, storage, renting, towing, leasing	876	876	1
Parts, tires, tubes, accessories	257	257	1
Automobile Insurance	207	207	1
Parking (excluding taxes)	6 7	6 7	1
Vehicle Inspection fees	0 8	0 8	1
Accident costs not covered by insurance	157	180	1
Garages and residential parking, including interest on loans	100	201	1
Losses from parking lot robberies and larceny or theft from cars[b]	01	0 2	1
Subtotal	5567	5693	
Highway freight transportation			
ICC-authorized intercity trucks	7 5 4	7 5 4	1
Non-ICC intercity trucks	8 5 2	8 5 2	1
Local trucks	11 8	111 8	1
Intercity buses	0 2	0 2	1
Government-owned freight trucks	5 5	5 5	1
Less wages of drivers (counted as time cost, table **4-7)**[c]	**1777**	**1777**	**-1**
Subtotal	$1004	$1004	
Deduction for user taxes and fees counted separately in this analysis	(39 2)	(39 2)	1
Total	**$617.9**	**$630.5**	

[a] **The low end is based on** *4-percent* discount rate and the high end on 2 5-percent discount rate

b The estimate accounts for the likelihood that if there were no motor vehicle use, some larceny thefts from motor vehicles and some parking lot robberies would become larceny theft of other things and robberies in other places The estimate does not Include the value of theft losses of motor vehicles, parts, and accessories, because it is assumed theft victims buy replacements for these items, and replacement purchases are Included on total national payments for vehicles, parts, and accessories, estimated elsewhere in this table The estimate also does not include payments for legal assistance, security services, or security devices (to the extent that they are costs of motor vehicle use and not already included in other lines in this table) because these costs proved too difficult to estimate

c The wage cost of **drivers** is **a** money **cost, and** technically belongs in this table It is included in table 4 7 to give a complete picture of the cost of all travel time

KEY ICC = Interstate Commerce Commission.

SOURCE M A. DeLuchi, University of California-Davis, *1994,* based on Federal Highway Administration data

Monetary Payments by Users for Highways and Services

Highway users pay for a large share of highway infrastructure and services through a variety of user charges. The primary source of payments is the Federal gasoline tax, which is now 18.4 cents per gallon, coupled with license fees and toll charges. State sales taxes represent an accounting difficulty: should these taxes, amounting to $14.3 billion, be counted as user charges (and included here in the total of motor vehicle user payments), or should only the small portion of sales taxes (about 3 percent) spent on highways be counted? The latter was chosen because sales taxes are collected on virtually all goods, not just gasoline, Table 4-3 displays the motor vehicle user payments counted toward highway infrastructure and services, about $70 billion in 1990.

As noted above, these fees are not marginal cost prices, and most of them do not fully cover costs. For example, the Federal excise tax on gasoline is a charge per gallon of gasoline consumed, and it is

TABLE 4-3: Payments by Motor Vehicle Users for Highway Infrastructure and Services, 1990 (billions)

Item	Low cost	High cost	Weight on cost
FHWA tax, license and toll payments by highway users	$443	**$443**	1
Portions of the tax dedicated to nonhighway purposes (Including collection expenses)	113	**113**	1
Other Imposts used for highways	3 0	3 0	0 1
Investment income from Highway Trust Fund	1 0	1 0	1
Extra highway user payments in 1991, over 1990a	7 4	7 4	1
Fees levied on producers	0 2	0 2	1
Sales taxes	143	143	0 0 3
Air quality and in lieu fees paid with vehicle registration (and not already counted)	0 6	0 6	1
Traffic fines	3.0	3 0	1
Parking fines	1 0	3 0	1
Parking taxes	0 7	0 8	1
Total	$70.3	$72.3	

[a] In December 1990, the federal gasoline tax was raised 5 cents/gallon, to 14 1 cents/gallon, of which 25 cents goes to reduce *the* Federal deficit (Federal Highway Administration, *Highway Statistics 1991, 1992)* There must also have been other Increases in user payments in 19!31 compared with 1990, because the extra revenue from the Federal tax does not account completely for all of the extra user payments in 1991 compared with 1990 As a result of these Increases, total user payments for transportation were about $7 billion higher in 1991 than in 1990 Gwen that this increase in payments has already occurred, it would be misleading if the baseline estimate did not account for it Consequently, the 1990 estimates have been adjusted so that the difference between cost and revenues is the same as in 1991, even though the baseline is nominally 1990 Note that the $7- billion difference between 1990 and 1991 is due mostly to differences in the rate of payment or expenditure per unit of vehicle use or ownership (the point of interest), rather than differences in total vehicle ownership or use In 1991 compared with 1990, total motor vehicle registrations were O 2 percent lower total vehicle miles traveled was 1 3 percent and total fuel gallonage taxed at prevailing rates was 1 6 percent lower (Federal Highway Administration, *Highway Statistics 7991, 7992)* These differences are small compared with the roughly 12 percent Increase in user payments from 1990 to 1991

KEY FHWA Federal Highway Administration

SOURCE M A DeLuchi, University of California Davis, 1994, on Federal Highway Administration data

designed to pay for highway infrastructure and maintenance. However, the amount of highway that a driver "consumes" depends on the type of highway (a freeway is orders of magnitude more costly per mile than a dirt road), the amount and kind of driving, the weight and other characteristics of a vehicle (a very heavy truck causes much more road damage, and necessitates a much heavier road, than does an auto), and other factors; the amount of gasoline consumed bears some relationship to these factors, but the relationship is a weak one.

Hidden Private Expenditures *for Motor Vehicles*

Table 4-4 displays those costs paid by the private sector for motor vehicle use that are ● *hidden" (not counted by motor vehicle users in their decisions about traveling). The largest expenditure is for parking: very few motorists pay for parking (according to the National Personal Transportation Survey, only about 1 to 2 percent of travelers during a typical travel day), but providers must still pay to build and maintain parking facilities. Estimates in the table represent both the "value" of parking, estimated by assuming that free parking would be charged at prevailing commercial rates, and the cost of parking, estimated by computing the likely actual expenditures needed to build, maintain, and operate parking facilities. Note that if all parking charged commercial rates, total parking demand would decline dramatically, and so might prices, as people carpooled, reduced tripmaking, and switched to other modes of transport to avoid charges. The "cost" estimate is considered the more accurate gauge of the social cost of free parking.

Another important hidden expenditure is the fraction of the monetary accident costs (property losses, medical costs, lost wages, etc.) of motor

TABLE 4–4: "Hidden" Private Sector Expenditures Related to Motor Vehicle Use, 1990 (billions)

Item	Low cost	High cost	Weight on cost
Value of free off street nonresidential parking at work (excluding parking taxes)	$3710	$6550	0
Value of free off street nonresidential parking for all other trips (excluding parking taxes)	6430	15230	0
Annual cost of off street nonresidential parking (excluding taxes), less payments for parking	4350	18520	1
Onsite roads provided by developers	500	1500	1
Monetary accident costs to those not responsible (and not covered by auto insurance)[b]	3260	3450	1
Monopsony cost of Importing oil	752	2162	1
Total	$88.60	$256.30	

[a] Roads built within the boundaries of the development, as opposed to roads outside the boundary (offsite roads, see table 4 5)
[b] The low end is based on a 4 percent discount rate estimate, and the high end on a 25 Percent discount rate

SOURCE M A DeLuchi, University of California Davis, 1994, on Federal Highway Administration data

vehicle use that is incurred by nonresponsible parties (both motorists and pedestrians) and not covered by automobile insurance,[17] more than $30 billion. These costs are considered hidden because the people who cause them do not pay for them and therefore do not consider them in travel decisions.

Another important but controversial hidden cost is the so-called monopsony cost of importing oil-the effect of the large U.S. import requirements on the world price of oil. A large reduction in U.S. oil imports presumably would lower world prices, saving all U.S. motorists a portion of their fuel bill (and providing savings for nontransportation users of oil, as well), but individual drivers do not take this potential savings into account. Calculating this cost demands estimating the sensitivity of world oil prices to U.S. oil demand, an uncertain and time-dependent value. A central value for this cost is about $15 billion, but the margin of uncertainty is very high.

Public Expenditures for Motor Vehicle Infrastructure and Services

Local, State, and Federal governments provide much of the infrastructure and services associated with motor vehicle use: highway construction, maintenance, and administration, police and fire protection, all aspects of the judicial system, and so forth. They pay for portions of accident costs not covered by insurance or private payments. And they pay for some aspects of national security associated with motor vehicle use of oil: military costs, and building and running the Strategic Petroleum Reserve. National security costs associated with relying on a fuel source whose primary reserves are located in politically volatile areas potential y represent the second largest governmental cost, after highway construction and maintenance. The range of expenditures is very large, however, because of accounting problems. Given U.S. commitments to the security of its political allies who also import oil, and given other U.S. interests as the remaining world superpower, would military expenditures to protect oil supplies necessarily be affected by large reductions in oil imports? Or how much of U.S. expenditures should be associated with its oil imports, and how much with the general importance of oil to world commerce, and thus to U.S. interests? Different answers to these questions yield very different estimates of U.S. military expenditures related to motor vehicle use. Table 4-5 lists these public expenditures.

[17] And not recovered by legal redress.

TABLE 4-5: Public Motor Vehicle Infrastructure and Services, 1990 (billions)

Item	Low cost	High cost	Weight on cost
Highway construction, maintenance, services, and administration (excluding costs of police and private investment in onsite local roads, but including collection expenses and private investment in offsite roads)	$76.5	$765	1
Pollee protection, including portion estimated by FHWA[a]	79	765	1
Fire protection	14	32	1
Court and judicial system[a]	40	100	1
Corrections[a]	25	35	1
Environmental regulation and government pollution control (e.g., sewers)	10	30	1
Energy and technology research and development	0.0	0.0	1
Military costs related to oil use	50	200	1
Strategic Petroleum Reserve construction, operation, and oil-holding costs	0.2	0.2	1
Monetary accident costs covered by the government (excluding pain, suffering, and lost quality of life)[b]	4.4	3.9	1
Other social services	0.0	0.0	1
Tax subsidies	0 0	3.0	1
Subtotal	$1030	$135.9	
Total: public infrastructure and services, net of Payments from table 4-3.	**$32.6**	**$63.6**	

a These estimates do attempt to account for the possibility that many criminal offenses that involve motor Vehicles and highways might occur anyway even if there were no motor vehicles and highways.
b The low end is based on a 4-percent discount rate and the high end on 2.5- percent discount rate

KEY FHWA = Federal Highway Administration.

SOURCE M A DeLuchi, University of California-Davis, 1994, on Federal Highway Administration data

Externalities

Table 4-6 presents some *rough* estimates of classic externalities associated with motor vehicle use. Although the term externality has many definitions, here externalities are nonmonetary damages imposed by motor vehicle users on others (including other motor vehicle users) without accounting for these damages. In other words, A affects B, but may not know it and, in any case, does not care. The monetary values for the externalities presented here are taken from the literature, with less evaluation than was applied to the monetary costs and expenditures in earlier tables. Typically, for most of these externalities, there are large uncertainties about both the physical magnitude of damages and the appropriate way to place monetary values on them.

Nonmonetary Personal Costs

Table 4-7 presents rough estimates of the nonmonetary personal costs of motor vehicle travel. The two important components of these costs are the value of travel time and the pain, suffering, and lost quality of life due to accidents for which the traveler is responsible. At an assumed cost of time of $4 to $7 per hour for motor vehicle occupants, travel time costs are huge; they are the single largest cost category in the entire set of social costs. The observed behavior of travelers makes it clear that they take significant account of travel time in their travel decisions; for example, travel time is a critical factor in choice of transport mode and one of the primary reasons why mass transit does so poorly in competition with auto travel. On the other hand, it is less clear that travelers take full

TABLE 4-6: Nonmonetary Costs ("Classical Externalities"), 1990 (billions)

Item	Low cost	High cost	Weight on cost
Pain, suffering, and lost quality of life inflicted on others, due to accidents	$132.1	$138.8	1
Macroeconomic costs of oil supply disruption	15.5	40,9	1
Mortality and morbidity effects of air pollution	40,0	200.0	1
Global warming due to fuel cycle emissions of greenhouse gases	2,5	25.8	1
Congestion travel time costs inflicted on others[a]	128.9	149,5	1
Leaking tanks, oil spills	1,0	3.0	1
oil refineries (environmental Impacts, excluding global warming)	1,0	6.0	1
Gasoline distribution (counted separately only if doing cost of gasoline use)	0.0	5.0	0
Agricultural losses	1.0	6.0	1
Material, visibility, and aesthetic losses due to air pollution	3.0	10,0	1
Noise inflicted on others	1,5	5.0	1
Total	**$325.5**	**$579.0**	

a This is a crude first approximation only, The breakdown between external Congestion cost and other travel time cost is conjecture

SOURCE M A DeLuchi, University of California-Davis, 1994, on Federal Highway Administration data.

TABLE 4-7: Nonmonetary Personal Costs, 1990 (billions)[a]

Item	Low cost	High cost	Weight on cost
Pain, suffering, and lost quality of life, due to accidents	$132.1	$138,8	1
Travel time, excluding external congestion costs[b]	855,4	992.0	1
Value of personal time spent working on cars and fixing and cleaning garages[c]	40,0	96,3	1
Pain, suffering, inconvenience, anxiety, and avoidance behavior due to crimes related to motor vehicle use	0.8	1.6	1
Personal noise costs[d]	0.0	0.0	1
Total	**$1,028.4**	**$1,228.7**	

[a] Personal nonmonetary costs are distinguished from nonmonetary externalities because of the different policy implications a Pigouvian tax on externalities (with no compensation for the victims), and a "reminder" to individuals about the personal costs that they inflict on themselves Technically, a small part of total air pollution damage, global warming damage, and other nonmonetary damage is actually borne by the party that generates it and thereby really is a personal nonmonetary cost rather than an externality However, for these damages, the personal cost is so much lower than the external cost that the distinction seems pedantic Only in the cases of accident costs, noise costs, and travel time is the distinction between personal and external costs of practical significance

b This is a crude first approximation only The breakdown between external congestion cost and other travel time cost is conjecture.

c Based on an estimated 8 to 11 minutes per person per day, and a $4-$7/Per Per hour time cost.

d No estimate has been made of the noise costs that motor vehicle users inflict On themselves.

SOURCE. M A DeLuchi, University of California-Davis, 1994, based on Federal Highway Administration data account of the potential for accidents, and the resulting injury costs, in their travel decisions. The recent sharp increase in consumer interest in vehicle safety, which has translated into vehicle purchase decisions beginning to focus on the presence of airbags, anti lock brakes, and other safety equipment, implies that safety is playing a strong role in *long-term* travel decisions: it is less clear to what extent safety influences short-term travel behavior.

Conclusions

Because different policy makers are more or less willing to incorporate nonmonetary costs into their decisions, and are more or less interested in equity among transportation alternatives versus economic efficiency, the numerical results of DeLuchi's analysis can be interpreted in a variety of ways.

The question of whether motor vehicle users as *a class* are paying most of the costs of their use is a good starting point. This is primarily a question of fairness, not economic efficiency.

First, if the focus is purely on monetary costs, motor vehicle users as a class pay openly[18] for most of the costs of motor vehicle use. In 1990, these payments ranged from $866 bill ion to $881 billion, while total motor vehicle use costs, including costs for free parking and the monopsony cost of imported oil, ranged from $988 billion to $1,200 billion; in other words, **motor vehicle users paid openly for** 73 **to** 88 **percent of the monetary costs of motor vehicle use.** Note that these costs include both "private" and "public'" costs.

Second, if all costs of motor vehicle use are considered, whether monetary or nonmonetary, including externalities such as the costs of oil supply disruption, global warming damages, and damages to vegetation and materials, but excluding the value of travel time, motor vehicle users "paid" about $988 billion to $1,019 billion in 1990, out of total social costs of $1,437 billion to $1,918 billion. In other words, **motor vehicle users paid openly for 53 to 69 percent of the social (public plus private) costs of motor vehicle use, both monetary and nonmonetary, excluding the value of time.** Further, to the extent that most of the accident costs listed as externalities are inflicted by users on other users, these could be added to the costs paid by users to yield a higher percentage of paid costs.

Third, because the costs of travel time (and other time spent in motor vehicles) are extremely high and paid entirely by motor vehicle users, adding time costs to the social cost equation leads to users' paying a much higher percentage of total costs. At average costs of $4 to $7 per hour for personal travel, the 1990 costs for motor vehicle travel time, excluding truck driver wages and external congestion costs, were about $718 billion to$911 billion. Thus, if all costs of motor vehicle use—monetary or nonmonetary (including travel time)—are considered, motor vehicle users "paid" about $1,716 billion to $1,930 billion out of total social costs of $2,155 billion to $2,937 billion. In other words, **motor vehicle users paid openly for 66 to 80 percent of the social (public plus private) costs of motor vehicle use, both monetary and nonmonetary, including the value of time.**

The general conclusion that can be drawn from these specific conclusions is that if subsidies were withdrawn, externalities "internalized," and hidden costs brought out into the open and directly charged to motor vehicle users, the perceived costs of motor vehicle use would increase substantially (by 14 to 89 percent, depending on whether nonmonetary costs and other factors are included), and people would drive less.

Another question that this analysis can answer is, are *motor vehicle users paying for the public services they receive?* Motor vehicle users paid $70.3 billion to $72.3 billion for highway in-

[18] That is, motor vehicle users paid for the costs in a manner that is clear and direct; thus the costs are likely to be taken into account in their travel decisions.

frastructure and services in 1990, out of public expenditures of $98.0 billion to $115.9 billion, not counting military costs related to oil use. If military costs are counted, public expenditures were $103.0 billion to $135.9 billion, depending on point of view. Thus, **motor vehicle users paid for 62 to 72 percent of public expenditures for highway infrastructure and services, not counting military expenditures, or 53 to 68 percent if military expenditures are counted.**

If economic efficiency is of primary concern, an attempt must be made to separate those costs that represent marginal costs to society and are paid and recognized by motor vehicle users, and those that do not fit this description.

Only the costs outlined in table 4-2—payments for motor vehicles, fuels, parts, service, and wages of freight drivers—satisfy the conditions for economic efficiency (the items in table 4-3, payments by motor vehicle users for highway infrastructure and services, are not considered to be efficiently priced). These costs amount to $796 billion to $808 billion out of total monetary costs of $988 billion to $1,200 billion, including the cost of free parking and the monopsony cost of importing oil. Thus, **approximately 67 to 81 percent of the total monetary costs of motor vehicle use are efficiently priced, that is, paid for entirely by motor vehicle users, counted in their travel decisions, and priced at marginal costs to society.**

If nonmonetary costs are considered as well, personal nonmonetary costs (table 4-7) may also be viewed as efficiently priced, although there will be arguments about the extent to which travelers properly account for some of these costs—particularly accident costs—in their traveling decisions. If these costs are efficiently priced, motor vehicle users efficiently paid for about $929 billion to $949 billion (or 49 to 65 percent) of total social costs, monetary and nonmonetary, of $1,437 billion to $1,918 billion, excluding the value of travel time. **In other words, approximately 49 to 61 percent of the total monetary and nonmonetary costs of motor vehicle use, excluding the value of time, are efficiently priced.**

An important caveat that must be attached to these conclusions is that they apply to a rather long-term perspective, with the focus on total costs rather than short-term, variable costs. The ratio of "accounted-for" costs to "unaccounted-for" costs would change substantially if only variable costs were being considered. In particular, a large component of the accounted-for costs is the cost of purchasing vehicles, which would not appear in a short-term accounting. And many of the unaccounted-for costs—such as free parking and environmental costs—are variable, and would remain in the travel budget when a short-term perspective is taken. Thus, in taking a short-term perspective, the ratio of accounted-for to total costs should be considerably lower than the ratios computed when both short-term and long-term costs were considered. Does this mean that moving to a system that forced travelers to account for all costs would affect their behavior more than is implied by the relatively small fraction of total unaccounted-for costs discussed above?

The question is, *which perspective-one that looks at total costs, or one that looks only at short-term, variable costs--best reflects how potential travelers will behave?* Certainly, if policy makers were concerned primarily about the impact on travel decisions that would occur immediate] y following a move to a "full cost accounting" system, they would focus on variable costs. However, travelers must eventually make decisions about vehicle purchases, insurance renewals, even the size garage they desire in a new home, and these decisions reflect both short-term variable costs, such as the cost of gasoline, and longer-term costs, such as vehicle purchase prices. These long-term decisions then greatly constrain travelers' future shorter-term decisions about how much to travel and which mode to use. Thus, both short- and long-term costs influence travel behavior.

No attempt has been made here to unravel the relative impacts on travel behavior of variable and long-term costs, although some data exist about certain elements of these impacts. Thus, no quantitative estimate is made of the extent to which a shift to an economic system that forces travelers to confront openly the total (marginal) social costs of their travel would impact both total travel and the distribution of travel modes. Nevertheless, OTA concludes that a shift to such an economic system would have important effects on travel, probably reducing its magnitude by a significant amount and *possibly* shifting the modal distribution. **OTA believes that further research on the subject of social cost estimation and the effects of transport pricing on travel behavior would be a valuable contribution to national transportation policymaking.**

CONGESTION

Analyses of the potential for reducing U.S. transportation energy use—and transportation planning in general-demand a reliable picture of current and future levels of highway congestion and its impacts, for two reasons. First, severe highway congestion may increase energy use by slowing travel speeds to a level at which internal combustion engines are relatively inefficient, and may increase or decrease energy use by affecting travel demand, travel patterns, and residential and business locational decisions. Second, at some level of severity, road congestion would place significant constraints on any transportation strategies that stress continued U.S. reliance on private vehicles for mobility. Some analysts fear that traffic congestion could become the Nation's primary problem in surface transportation by the 1990s,[19] and could cause average travel speeds to slow greatly—and travel times to soar—soon after the turn of the century. Congestion of this severity clearly would affect the relative priority transportation strategists would give to, say. new transit systems versus improved vehicle efficiency. Other analysts have expressed skepticism that congestion problems are as severe as they have been portrayed, or that the future will be as bleak as predieted. The validity of the available congestion estimates and forecasts must be examined carefully.

Some analysts fear that traffic congestion could become the Nation's primary problem in surface transportation by the end of the 1990s

■ Proposition: There Is a Major National Congestion Problem

Some recent analyses of highway congestion conclude that growing congestion is an extremely serious problem for the U.S. highway system. The Federal Highway Administration (FHWA) has completed a number of congestion studies whose results point in this direction:

> By all system performance measures of highway congestion and delay, performance is declining. Congestion now affects more areas, more often, for longer periods, and with more impacts on highway users and the economy than at any time in the Nation's history.[20]

For example, FHWA has determined that the percentage of *highway mileage* in which peak-hour

[19] U.S. General Accounting Office, *Traffic Congestion: Trends, Measures, and Effects*, GAO/PEMD-90-1 (Washington, DC: November 1989.

[20] U.S. Congress, *The Status of the Nation's Highways and Bridges: Conditions and Performance*, Report of the Secretary of Transportation (Washington, DC: U.S. Government Printing Office, 1991).

travel occurs in congested conditions[21] rose sharply between 1983 and 1989: on rural interstate, from 3 to nearly 10 percent; and on urban interstates, from 31 to 46 percent.[22] Similarly, the percentage of total *peak-hour travel* occurring in congested conditions rose in the same time frame: on rural interstates, from 8 to nearly 23 percent, and on urban interstates, from 55 to nearly 70 percent.[23] More importantly, most of the peak-hour travel under congested conditions was rated as "highly congested" by FHWA standards.[24]

FHWA examination of severe congestion in a 20-city sample shows similar results. In the sample, FHWA estimates that the percentage of total freeway travel operating under severely congested conditions—level of service F, where traffic is highly unstable and likely to degenerate into stop and go-rose from 5.2 to 6.4 percent during 1985-88.

The Texas Transportation Institute (TTI) also has studied national congestion trends. Table 4-8 presents estimates of changes in values of the roadway congestion index (RCI) from 1982 to 1988. The index is a simple measure of congestion, measuring the daily vehicle-miles of travel per lane-mile of road on freeways and principal arterial roads; an increase of 10 percent in the index means that the growth in vehicle-miles of travel has outstripped roadbuilding (the growth of lane-miles) by 10 percent. RCIs greater than 1.0 are considered to indicate congested conditions, although the average highway speeds generally achieved at RCI = 1.O—a bit more than 40 miles per hour (mph)—would not be considered slow for urban freeways in dense cities.

As shown in table 4-8, in 28 of the 39 cities, the growth in vehicle-miles traveled (vmt) on highways and principal arterial roads outstripped increases in lane-miles by at least 10 percent, and in several cases by well over 20 percent, in just 6 years.

Estimates of the costs of congestion—including time delays, wasted fuel, and increased insurance premiums[25]—indicate that these costs are high. Available studies generally conclude that total costs are in the tens of billions of dollars and are rising rapidly. For example, TTI estimated congestion costs for 39 of the Nation's largest metropolitan areas to be more than $34 billion in 1988.[26]

Some studies have attempted to project future congestion levels by extrapolating trends in highway travel and road building, Their results, in project ions of congestion levels and average highway speeds, appear extremely worrisome. For example:

1. FHWA has projected that by 2005, in the absence of further highway improvements or growth, 23.9 percent of all freeway trave1[27] will be at least mildly congested—that is, traffic will slow from true free-flowing conditions—simply from normal daily peaks in traffic, not

[21] Volume to capacity (V/C) ratios of 0.80 or greater; for urban freeways, a V/C ratio of 0.77 corresponds to an average speed of about 54 miles per hour, and a ratio of 0.80 corresponds to a slightly lower speed. U. S. General Accounting Office, op. cit., footnote 19, table 3.1.

[22] U.S. Congress, op. cit., footnote 20.

[23] Ibid. The travel values are higher because these segments carry more traffic than uncongested segments.

[24] V/C of 0.95 or greater, corresponding to average speeds of about 40 to 45 miles per hour or less according to the U.S. General Accounting Office, op. cit., footnote 19, table 3.1.

[25] Other costs, generally not estimated, include excess vehicle wear and driver stress.

[26] J.W. Hanks, Jr. and T.J. Lomax, *Roadway Congestion in Major Urban Areas 1982 to 1988*, Report No. FHWA/TX-90-1131-3 (College Station, TX: Texas Transportation Institute, July 1990).

[27] Measured in vehicle-miles.

TABLE 4-8: Change in Roadway Congestion Index, 1982-88

Urbanized area	1982	1988	Percent change 1982-88
Phoenix, AZ	1.15	1.00	-13
Detroit, MI	1.13	1.09	-4
Houston, TX	1.17	1.15	-2
Memphis, TN	0.86	0.86	0
Cincinnati, OH	0.86	0.88	2
Pittsburgh, PA	0.78	0.81	4
Louisville, KY	0.84	0.87	4
Corpus Christi, TX	0.67	0.70	4
Philadelphia, PA	1.00	1.07	7
Oklahoma City, OK	0.72	0.78	8
New York, NY	1.01	1.10	9
Baltimore, MD	0.84	0.92	10
Tampa, FL	0.94	1.03	10
Miami, FL	1.05	1.18	12
San Antonio TX	0.77	0.86	12
Milwaukee, WI	0.83	0.94	13
Fort Worth TX	0.76	0.87	14
Salt Lake City, UT	0.63	0.72	14
Albuquerque, NM	0.78	0.90	15
Chicago, IL	1.02	1.18	16
Kansas City, MO	0.62	0.72	16
Denver, CO	0.85	0.99	16
El Paso, TX	0.63	0.74	17
Indianapolis, IN	0.71	0.84	18
St Louts, MO	0.83	0.98	18
Minneapolis-St Paul MN	0.74	0.88	19
Cleveland, OH	0.80	0.97	21
Dallas, TX	0.84	1.02	21
Portland, OR	0.87	1.05	21
Washington DC	1.07	1.32	23
Seattle-Everett WA	0.95	1.17	23
Boston MA	0.90	1.12	24
Atlanta, GA	0.89	1.10	24
Austin, TX	0.77	0.96	25
Los Angeles CA	1.22	1.52	25
Sacramento, CA	0.80	1.03	29
San Francisco-Oakland, CA	1.01	1.33	32
Nashville, TN	0.74	0.99	34
San Diego, CA	0.78	1.13	45
Northeastern average	093	1.06	
Midwestern average	083	0.92	
Southern average	090	1.03	
Southwestern average	082	0.90	
Western average	094	1.21	
Total average	087	0.99	
Maximum value	122	1.52	
Minimum value	062	0.70	

SOURCE J W Hanks Jr and TJ Lamas. Texas Transportation Institute, *Roadway Congestion in Major Urbanized Areas 1982 to* 1988, FHWA/TX-90-1131-3 (College Station TX July 1990) counting accidents or other singular events.[28] In 1984, only 11.4 percent of freeway traffic was congested because of normal traffic peaks. The same analysis projects total delay from both normal peaks and singular events of nearly 7 billion vehicle-hours, from slightly more than 1 billion vehicle-hours in 1984-an increase of 450 percent. Similarly, excess fuel consumption is projected to increase from 1.378 billion to 7.317 billion gallons per year, a 431 -percent increase .29

2. Various local studies have projected sharp declines in service because of congestion. For example, Los Angeles freeway speeds are projected to slow to 11 mph from their present 31 mph by 2010.30 Planners for Southern California projected in 1988 that average freeway speeds would drop by 50 percent and speeds on other roads by 46 percent, to 24 and 19 mph, respectively, within 20 years.[31]

Neither the estimates of changes in actual congestion levels nor the forecasts of future congestion appear at odds with areawide data on highway travel and highway capacity. These data show that travel has been increasing at a far greater rate than capacity; for example, vehicle-miles increased by 168 percent during 1960-87 (3.7 percent per year), whereas highway mileage increased by only 9 percent.[32] And while vehicle-miles are expected to increase more slowly in the future, it remains a virtual certainty that future travel growth will continue to outstrip highway building, at least for the next few decades.

Counterarguments

Despite these trends, some analysts have questioned the high estimates of congestion costs made by FHWA and others. They have focused particularly on travel data that, on the surface, appear to contradict the estimates. One such "contradictory" data set is the available survey data on commuting times; although local commuting times have changed, the national average commuting time has been remarkably stable over the past decade. Two major surveys measuring recent changes in commuting times showed little change during the 1980s: the national census estimates that average commuting times increased by 40 seconds between 1980 and 1990, from 21.7 to 22.4 minutes;[33] the National Personal Transportation Survey (NPTS) estimates that they declined by about 40 seconds during 1983-90.34 An examination of commuting times in 20 cities showed that between 1980 and 1985, 18 of the 20 cities experienced a decrease in commuting times. 35 Although commuting represents only 32 percent of all

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[28] J. Lindley, "Urban Freeway Congestion: Quantification of the Problem and Effectiveness of Potential Solutions, *ITA Journal*, vol. 57, No. 1, January 1987.

[29] Ibid.

[30] "Transportation and Land Use, Bridging the Gap, " *Developments*, the Newsletter of the National Growth Management Leadership Project, spring-summer 1990, p. 2, in J .J. MacKenzie et al., *The Going Rate: What It Really Costs To Drive* (Washington, DC: World Resources Institute, June 1992).

[31] Southern California Association of Governments, *Regional Mobility Plan* (Los Angeles, CA: 1988), cited in P. Gordon et al., "The Commuting Paradox: Evidence From the Top Twenty," *American Planning Association Journal*. autumn 1991.

[32] U.S. General Accounting Office, op. cit., footnote 19.

[33] A E Pisarski *New Perspectives in Commuting* (Washington, DC: U.S. Department of Transportation, Federal Highway Administration, July 1992).

[34] P.S. Hu and J. Young, *Summary of Travel Trends; 1990 Nationwide Personal Transportation Survey*, FHWA-PL-92-027 (Washington, DC U.S. Department of Transportation, Federal Highway Administration, March 1992), table 10.

[35] P Gordon et al., op. Cit., footnote 31, pp. 416-420. The reduction in commuting times represents both a Small decrease In average worktrip length and a small increase in speed.

household personal vehicle miles-traveled,[36] it almost certainly represents a substantially larger share of *congested* vehicle-miles traveled. Thus, it is not easy to reconcile the idea of huge increases in congestion and little change in commuting times.

Also, contrary to what might be expected from the thesis that urban congestion—and bumper-to-bumper traffic moving at a crawl—is spreading, essentially all nationwide measures of highway speed (average, median, percentage exceeding 55 mph, etc.) show increases. For example, average speeds[37] on urban interstate highways rose from 55.5 mph in 1981 to 58.6 mph in 1990; similarly, average speeds on other urban freeways and minor arterials rose from 55.0 to 57.6 mph in the same time.[38]

Further, if congestion is such a problem, drivers making unscheduled trips would be expected to avoid peak traffic periods. Although available data do not distinguish clearly between unscheduled and scheduled trips, NPTS data on peak-hour travel reveal that trips *other than* commuting account for 63 percent of all trips in metropolitan areas during the morning and afternoon peaks (6 to 9 a.m. and 4 to 7 p.m.).[39] Although many of these trips (e.g., parents driving children to school) cannot be shifted to other times, it seems likely that others could be taken at off-peak hours. The willingness of drivers to make so many of their nonwork trips during peak hours may imply that many do not consider current congestion levels severe; it also implies the existence of some potential to hold off increased congestion (presumably, at some congestion level, drivers *would* switch to other times).

Evaluation

Do these seeming contradictions mean that either the congestion estimates or the "opposing" data sets are incorrect, or can both be correct? Although the data do not allow a definitive conclusion, it appears likely that the trends of stable commuting time and rising highway speeds could coexist comfortably with rising congestion, at least for a while, There are reasons to doubt, however, that current congestion impacts are as severe as portrayed or that they will necessarily grow as rapidly as forecast. On the other hand, traditional estimates of the economic impacts of congestion tend to ignore some of its important negative consequences.

First. the failure of commuting trips to show significant increases in average time may reflect the effects of one trend being canceled by a few others. That is, although congestion may indeed be growing, which should tend to increase travel times, a variety of factors (e.g., a shift in commuting patterns to suburb-to-suburb routes and a larger percentage of single-rider commuting, thus reducing the average number of stops necessary and trip circuity) would act in the opposing direction to reduce travel times.

Although the data show clearly that total vehicle-miles traveled has grown much faster than total road capacity, there have been important shifts in trip patterns that counteract at least some of the potential congestion impacts of the vehicle-miles traveled versus capacity trends. In particular, there has been a continuing shift of worktrips from central city to suburbs: between 1970 and 1980, for example, central-city to central-city

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[36] S.C. Davis and M.D. Morris, *Transportation Energy Data Book*, ed. 12, ORNL-6710 (Oak Ridge, TN: Oak Ridge National Laboratory, March 1992), table 4.9.

[37] These are weighted by traffic flow over a 24-hour period, not by time, so that the reported values are the speeds averaged over all cars on the road during the day. Ken Welty, Federal Highway Administration, personal communication, Feb. 10, 1993.

[38] U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics* (Washington, DC: 1981-1990), tables VS-1, VS-2.

[39] H.W. Richardson and P. Gordon, University of Southern California, "New Data and Old Models in Urban Economics," preliminary draft, December 1992, table 3.

commuting trips declined as a percentage of all commutes by nearly 18 percent, whereas suburb-to-suburb commuting trips increased by 20 percent, and these trends have continued.[40] This appears to be a crucial reason why average commuting times have not escalated. Even if congestion is growing in some areas, many workers have escaped it. Suburban trips are likely to be made under less congested conditions and thus at higher speeds, and they are more likely to be made in autos than on transit, also reflecting lower door-to-door times. In fact, worktrip speeds have increased over time for both central-city and suburban residents, except for those driving off-peak.[41] Evidence is less clear about whether changes in the time of day that trips are made may also have played a role in reducing the impacts of congestion. Although there has been much anecdotal discussion of workers' attempting to avoid the worst congestion by arriving at work significantly earlier than they are expected (or leaving later) or taking advantage of flextime schedules, analysis of American Housing Survey data shows little evidence of peak elongation in the smaller metropolitan areas.[42]

If, *at the national level,* large shifts in travel patterns are compensating for the failure of highway capacity to keep up with growing travel, substantial geographical differences should still show up in the data since there are large differences in growth rates among cities, and large differences among urban areas in their willingness to expand highway capacity. Such differences do appear to exist.[43] For example, during 1980-90, Los Angeles gained 2 minutes in average commuting time, and some of the nearby counties had gains that were much higher; whereas Houston, despite a large growth in commuting traffic, *lost* 1.7 minutes during the period. On a State-by-State basis, New Hampshire showed the largest percentage increase—about 13 percent—while Wyoming showed a 13 percent decline in commuting time.[44]

Another trend that would tend to reduce commuting time is the growth in the percentage of workers driving alone. According to census data, in 1980 single-occupancy vehicles accounted for 64.4 percent of commute trips; in 1990 this mode accounted for 73.2 percent of all such trips,[45] a gain of 22 million single-occupancy vehicles during a period when the total number of workers increased by only 19 million.[46] In the same period, commuting on public transportation declined from 6.4 to 5.3 percent of all commute trips, and carpooling declined from 19.7 to 13.4 percent, with nearly half of the decline coming from carpools of three or more riders.[47] Transit trips and carpool trips tend to be relatively long (because of waiting time and access time for transit, and pickup-dropoff time for carpools; even when husband and wife drive together, one generally drops the other off at a work location, with added distance and dropoff time).

Second, the data on highway speed may also reflect two opposing trends. Increases in average highway speeds could simply result from the combination of speed increases at off-peak hours and (congestion-caused) decreases at peak hours, with the increases thus far outweighing the decreases.

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40 P. Gordon and H. Richardson, "Notes From Underground: The Failure of Urban Mass Transit," *The Public Interest,* Issue 94, winter 1989, table 1.

41 P. Gordon et al., op. cit., footnote 31.

42 Ibid.

43 Pisarski, op. cit., footnote 33.

44 Ibid., figure 12.

45 Ibid., table 2.

46 Ibid.

47 Ibid.

As a hypothetical scenario, in 1990,off-peak[48] trips accounted for about 54 percent of total trips in metropolitan areas.[49] If off-peak highway trips are usually uncontested, the actual 2.6 to 3.1 -mph speed increase on urban highways during 1981-90 could have resulted from a 2.5 to 3.O-mph *decrease* in speed during peak hours due to congestion and about a 5.0 to 6. O-mph *increase* during off-peak hours due to more drivers exceeding speed limits.[50] Unfortunately, FHWA does not have time-of-day data on highway speed: further study using State data is necessary to determine the validity of the above hypothetical scenario.

Third, although the estimated costs of congestion appear very high. they may be relatively low *compared with the total volume of travel.* The present amount of congestion seems quite drastic because of current rhetoric and because the aggregate estimates of "congested" roads and monetary damages seem very high. For a variety of reasons. however, the impact on the average driver may not yet be all that great, although it may get much worse.

"Congested flow" in FHWA terminology means only that traffic has slowed from total 1 y unconstrained levels: 54-mph speeds on freeways represent congested conditions under this definition. Even FHWA's "highly congested" traffic flow (volume-to-capacity (V/C) ratio greater than 0.95) implies average speeds of about 40 mph or less,[51] which includes traffic that would be considered quite free-flowing by most residents of large urban areas. Interestingly. FHWA, in its report to Congress, slightly misinterprets its own congestion data:[52] it reports that 70 percent of peak-hour travel on urban interstate is experiencing level E service or worse[53] (E is severely congested). whereas the 70 percent value actually refers to V/C levels of 0.80 or more, which is closer to level C service. or very mildly congested.

To get a better fix on congestion impacts, it makes sense to compare the estimated total delay time caused by congestion with the total time of travel. As noted, FHWA estimates that congestion delay in 1984 was about 1 billion vehicle-hours and will increase to more than 7 billion vehicle-hours by 2005. TTI's estimate of the vehicle hours of delay in 1989 for 50 major urbanized areas (with a combined population of 103 million) is 2.46 billion.[54]

The FHWA estimate is a relatively small number of hours compared with total highway vehicle-hours: in 1983. about 15 billion vehicle-hours were devoted to commuting, and perhaps 40 to 50 billion vehicle-hours to trips of all purposes.[55] If half of the delay hours affected commuting trips,

[48] That is, outside of the 6 to 9 a.m. and 4 to 7 p.m. peaks

[49] Richardson and Gordon, op. cit., footnote 39, table 3.

[50] These hypothetical values assume that nonpeak and peak trips are equally likely to be on highways and that their highway trip distance is the same.

[51] Given the relationship between speed and V/C that was thought to exist at the time the report was written. Recent data suggest that at a V/C of 0.95, highway speeds would average about 55 mph; that is, speeds do not drop off severely until a V/C of 1.0 is reached. See discussion later in this section about recent revisions of the Highway Capacity Manual.

[52] U.S. Congress, op. cit., footnote 20, p. 146.

[53] Ibid.

[54] J.W. Hanks, Jr. and T.J. Lomax, *1989 Roadway Congestion Estimates and Trends*, FHWA/TX-90-1131-4 (College Station, TX: Texas Transportation Institute, July 1992.

[55] We know of no direct estimates of total hours spent for commuting and for highway travel in general, but these can be estimated from the National Personal Transportation Survey (NPTS) and from Oak Ridge data on vehicle-miles traveled. According to the NPTS, 1983 *household* vmt for all purposes was 1.002 trillion miles; and according to the Oak Ridge data book 12, table 3.2, auto and light truck vmt in 1984 was 1.592 trillion miles. Assuming an average travel speed of about 40 mph yields a total travel time for all 1983 trips of about 40 billion vehicle-hours with the higher Oak Ridge figure, which is probably the more appropriate value. The commuting time was estimated by using NPTS data showing 103 million workers in 1983, each traveling about 20 minutes per commute; assuming 250 working days per year and approximately 1.2 workers per vehicle yields about 15 billion vehicle-miles.

then the delay for the average commuting trip in 1983-84 was about one-thirtieth of 20 minutes--40 seconds per trip. However, FHWA's projected 450-percent increase in delay time by 2005 will have far greater impact, because in that period the total number of commuting trips is likely to increase by only about 50 percent over the 1983 value, which implies an average delay of about 3 minutes per trip.

The TTI estimate implies a more substantial impact on the average trip. Even if the sample of 50 urban areas includes a much higher percentage of the Nation's total congestion than is implied by its portion (less than 50 percent) of the total U.S. population, the estimate seems to imply an impact on commuting trips of at least 2 minutes per trip, compared with FHWA's 40 seconds.

It is not easy to interpret these congestion values, particularly because the averages almost certainly hide strong distributional impacts. Even at the higher TTI figure, it is not clear that current levels of congestion represent a substantial inconvenience to the *average* driver at most times. The TTI congestion delay estimate implies that congestion costs the average city dweller about 30 hours per year, or 5 minutes per day. On the other hand, it is entirely possible that the distribution of congestion impacts is strongly skewed, so that a minority of drivers is impacted very heavily. Unfortunate y, available analyses of congestion costs do not attempt to evaluate how the impacts are distributed.

Although the above arguments imply that the trends in highway speeds and commuting times do not really contradict FHWA and TTI estimates of congestion, other evidence implies that the estimates are overstated. FHWA and other organizations that estimate congestion damages do not rely directly on speed data to calculate congestion delays; instead, the organizations *estimate* speed by collecting data on traffic flows and applying known relationships between traffic flows and speed. In one of its estimates, for example, FHWA applies traffic flow-speed relationships derived from 1983 and 1984 traffic counts on Interstates 66 and 395 near Washington, DC.[56] Another, widely used source for traffic flow-speed relationships is a set of graphs of average speed versus volume of passenger cars per lane published by the Transportation Research Board (TRB).[57] New research shows that the old graphs are not accurate anymore; today's drivers are able to maintain higher speeds with high traffic counts than their counterparts in the past. Therefore, applying the old (1985) TRB curves would yield estimated speeds that are too low and estimated delays that are too high. Figure 4-1 compares the 1992 curve for freeways and multilane highways with its counterparts for 1985 and 1965. The curve shows that in 1992, the actual capacity of each freeway lane is at least 2,200 cars per hour, rather than 2,000 cars per hour for the earlier years. Furthermore, there is now essentially no dropoff in speed until traffic flows reach 1,400 cars per hour per lane, and after that the dropoff is relatively mild. The curves for earlier years show an immediate dropoff as traffic increases from zero, and the beginning of a sharp dropoff at about 1,600 cars per hour per lane.

By using the old curve, highways at traffic counts of 2,000 cars per hour per lane would be estimated to be close to gridlock, with average speeds of about 30 mph. Each of the 2,000 cars would be accumulating '*delays" of about 5 minutes for every 10 minutes actually on the highway, By using the new curve, however, average speeds for this situation are estimated to be 55 mph, with essentially no delays. Because the data used by FHWA in its congestion analyses are similarly

[56] U.S. General Accounting Office, op. cit., footnote 19.

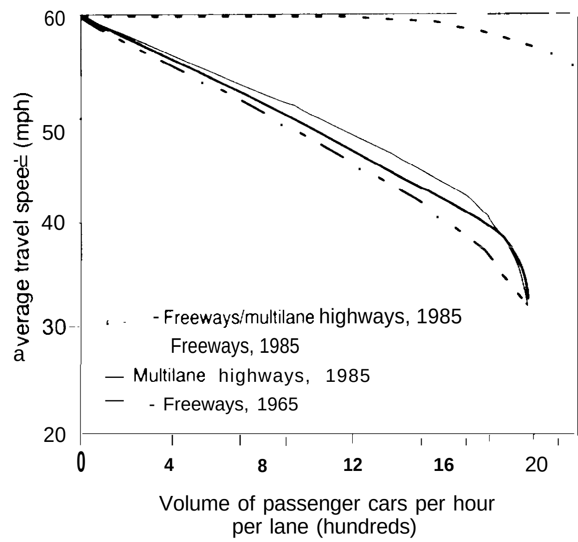
[57] Transportation Research Board, *Highway Capacity Manual*, Special Report 209 (Washington, DC: 1985).

outdated, its congestion damage estimates are overstated.

A reanalysis of urban freeway congestion delays by FHWA[58] using the revised capacity of 2,200 cars per hour per lane and the revised speeds for V/C less than 1.0 indicates that the estimated 1987 vehicle-hours of delay are reduced by 12 percent with the new data. This reduction seems surprisingly small given the severity of the change in figure 4-1. The author of the reanalysis explains that most of the delay occurs at very high V/C levels, particularly during non-reoccurring events, so that the changes have no effect on the greatest portion of the delay.[59] The accuracy of both the original analysis and the reanalysis depends, however, on the accuracy of a key assumption used in both calculations, that average travel speed at V/C levels greater than 1.0 is 20 mph. No data exist to allow a reliable representation of this average speed.

Even if congestion impacts are spread relatively widely and are lower than FHWA has estimated, yielding a somewhat milder view of the current problem, the question of future impacts remains. As noted, congestion is projected to increase rapidly in the future. This is not surprising, given its nature: once traffic reaches a threshold of congestion—about 80 to 90 percent of the design capacity of the road[60]—average speeds drop (and delays increase) rapidly with increasing traffic flows. What the FHWA data seem to show is that traffic flows on a large percentage of U.S. highways have passed the congestion threshold for several hours per day; thus, if traffic continues to increase at historic rates with increases in road capacity lagging behind, congestion will increase very quickly. Presumably, an analysis based on the TTI methodology would yield still higher estimates of future congestion impacts. Although OTA believes that a reanalysis of congestion impacts using the most recent data on speed-traffic flow relationships would yield a reduced estimate of current congestion impacts, this is not to deny that congestion problems exist.

FIGURE 4-1: Alternative Highway Speed-Traffic Volume Relationships



SOURCE 1965 Highway Capacity Manual Highway Research Board (HRB) Washington DC 1985 Highway Capacity Manual," Transportation Research Board *Highway Capacity Manual* Special Report No 209 (Washington DC National Research Council 1985) data from National Cooperative History Research Program Project 3-33 "Capacity and Level of Service for Multilane Highways

The importance of congestion in the future depends on the growth rate of vehicular travel; infrastructure responses (new roads, improved maintenance of roadways, smart highways); behavioral responses of drivers and businesses, either spontaneously or reacting to government incentives: and general trends in urban structure. The actual degree of congestion to be expected in future years should be very sensitive to changes in these vari-

[58] J.A. Lindley, Federal Highway Administration, "Supplemental Analysis of Urban Freeway Congestion Using Revised Capacity and Speed-Flow Relationships," unpublished paper, April 1993.

[59] J.A. Lindley, Federal Highway Administration, personal communication, 1993.

[60] The higher value reflects more recent data on traffic flow-speed relationships.

ables. For example, increasing highway capacity by 20 percent by 2005 would decrease the expected traffic delay by about 27 percent, according to the FHWA model.[61]

No similar analysis is available for possible changes in travel behavior caused by continuing changes in jobs and residential locations, as well as other changes such as varying work hours and shifting of peak-hour nonwork travel out of the peak. The FHWA model does not consider such changes, and data to allow such consideration may not be available. Changes in travel patterns, however, probably could have impacts on congestion at least as strong as the likely increases in highway capacity, especially as congestion becomes severe. Questions that need to be asked, and investigated, include: Will growing congestion cause more workers to change jobs or residences? Will businesses relocate to less congested areas, change their business hours, or perhaps establish remote annexes connected by telecommunications?

Trends in urban land use and travel patterns have tended over the past few decades to mitigate the impacts of rapidly growing travel and slowly growing road capacity, by shifting travel away from congested routes. Unfortunately, it is not clear to what extent congestion played a key role in the important shifts in job and residential locations that have occurred over this time period. In all probability, the shifts in job locations owed as much or more to advances in telecommunications and the general degradation of urban services as they did to congestion. Similarly, movement of workers to the suburbs reflected growing urban crime and degenerating school systems, as well as a desire for single-family housing, at least as much as it reflected an escape from congestion. In other words, although past trends worked well to reduce the impacts of congestion on commuting, *it is unlikely that the primary causal factor behind these trends was the congestion itself.* Consequently, it may be risky to assume that businesses and workers will adapt their behavior to growing congestion in the future and thus mitigate it, unless other forces push their decisions in the same direction. Also, the locational shifts of the past may have reduced the growth of congestion in the cities, but they introduced congestion to the suburbs and beyond. If recent trends in job creation continue, the suburbs will gain population and employment. Increases in congestion will then depend on just where this growth occurs—in the already developed portions of the suburbs or in new outer rings of development. Congestion will also depend on whether additional suburban growth concentrates in subcenters or, as some predict, develops in a more uniform character.

Despite the uncertainty, however, it is difficult to believe that the forecasts of extreme drops in travel speeds will prove correct. The forecasting models assume that congestion does not have some self-limiting mechanisms, that is, that traffic will simply keep on increasing as highway speeds fall. It seems more likely that, instead, growing congestion will restrain growth in traffic volumes and shift travel to less congested areas and less congested times, especially when average speeds drop severely. Unfortunately, there are few data on the nature of the effect—the critical speeds beyond which driver behavior might shift strongly, regional differences in driver tolerance of delay, etc.

Aside from concern about the accuracy of current estimates and projection of future congestion delays, estimates of the *dollar costs* of congestion must be treated with care as well. TTI computes costs in three categories-insurance, delay, and fuel. Insurance costs represent the difference between costs in smaller urbanized areas and those in large urban areas.[62] Attributing these differences solely to congestion is unwise, however; higher insurance rates in large urban areas are like-1 y to be due to higher rates of auto theft, existence of more intersections and more traffic regardless

[61] U.S. General Accounting Office, op. cit., footnote 19, table 4.3.

[62] Hanks and Lomax, op. cit., footnote 26.

of congestion, more interaction between pedestrians and traffic, and other factors in addition to congestion. Estimates of fuel costs calculate increased fuel use by applying fuel economy adjustment factors obtained from empirical evaluation of automobiles operating at different speeds. Although maintaining high-efficiency levels at low speeds is a problem for auto designers, a large growth in congestion could conceivably spur redesign of vehicle drivetrains to reduce the low-speed fall off in efficiency. This redesign would be facilitated by a shift by the U.S. Environmental Protection Agency in its city-highway adjustment factors, or in its test cycle, to account for changes in driving patterns.

Estimates of delay costs assign an hourly value to lost time (in the TTI study, $8.25 per person-hour) and calculate delay as time lost by driving at speeds below the off-peak average. These estimates implicitly assume that extra time spent in vehicles is wasted. Certainly many would agree with this, but the extreme comfort levels attained in modem vehicles (including high-quality stereo systems and portable phones) may begin to challenge this assumption.

To our knowledge, both TTI and FHWA focus on direct delays attributed to congestion, and do not attempt to quantify the economic impact of congestion-caused changes in travel behavior: the need to schedule extra travel time because of increased *variability* of commuting time due to congestion; and forced shifts in destinations and times, or even foregoing travel because of congestion. These impacts may be quite significant, although clearly they are difficult to measure.[63]

TTI's methodology averages areawide traffic flows with areawide measures of capacity, and may have difficulty correctly gauging actual changes in congestion levels if tripmaking patterns change over time, which they have. FHWA's methodology *appears* to measure individual sections of roadway and average these. Congestion estimates using this methodology would not appear to be easily distorted by changes in travel patterns.

If commuting trips are not getting longer *on average,* but large increases in travel delay are occurring, this could mean that most of the direct impacts of congestion are falling on nonwork trips for shopping, social and recreational purposes, and other family or personal business. Certainly, the time spread of congestion now impinges on trips that once avoided congestion simply by avoiding the traditional "rush hour." Also, the spread of suburbanization and the large movement of women into the workplace may have added enough jobs with short commutes to balance congestion effects on those workers remaining in traditional commuting patterns, so that the data on average commuting time may be hiding strong congestion impacts affecting many workers. Finally, congestion may affect even those workers who have changed jobs and residences and shortened their commuting times; without the added congestion, they would have saved still more time.

To conclude, congestion on U.S. urban and suburban highways is an important and growing problem, but the magnitude of the problem is not well defined. Current congestion levels are not well measured, and available forecasts of future congestion levels appear simplistic. Some analysts believe that FHWA estimates of current congestion levels, and its characterization of the nature of the congestion problem, are grossly overstated. Evidence that appears to contradict the FHWA estimates (constant commuting times, increasing average highway speeds) turns out to be equivocal, however, when examined more carefully. At FHWA-estimated levels, congestion delays are still a small fraction of total travel times during peak hours. Thus, it is not unlikely that congestion at these levels could fail to impact

63 Recommendations for paying more attention to these impacts appear in A.E. Pisarski, *Summary and Recommendations of the Workshop on National Urban* Congestion Monitoring, FHWA-PL-90-029 (Washington, DC: U.S. Department of Transportation, Federal Highway Administration, September 1990).

measures such as average commuting times, especially when recent changes in commuting patterns are factored in. If congestion does grow as rapidly as forecast, however, the efficiency of the U.S. highway system could be seriously degraded. Given this potential threat, upgrading of congestion measurements and forecasts is a worthwhile goal.

ENERGY SECURITY AND TRANSPORTATION

The high levels of U.S. oil imports and the near-absolute dependence of U.S. transportation on oil—as well as a similar or worse situation for its major allies—represent a threat to U.S. energy and economic security. Yet, neither the price of gasoline nor the prices of other cost components of petroleum-based transportation includes any premium or tax directed at reducing the danger or potential cost to the U.S. economy of a future oil disruption or at establishing a fund to pay for future actions the United States might be forced to take to prevent or reverse such a disruption. This threat to U.S. security is one of several external costs whose absence from the price of travel artificially boosts oil consumption above the level that would be achieved if these prices reflected the full social costs of travel. There are severe disagreements, however, about the magnitude of the costs associated with this security loss.

If domestic oil production continues to fall and U.S. oil demand continues to increase, oil imports will soon surpass 50 percent of consumption. Congress clearly viewed the high levels of oil imports of the 1970s as a threat and responded with extensive legislation establishing programs to promote synfuels development, tax incentives for energy conservation and alternative energy sources, an extensive energy research and development program, **and** the **construction** of the Strategic Petroleum Reserve (SPR). In addition, Congress appropriated funds to establish military forces specifically designed to deal with threats far from established U.S. military bases (e.g., in the Middle Eastern oil fields).

Industry supporters of congressional measures to fight increases in U.S. oil imports, especially measures to boost domestic oil production, have portrayed the potential import increases in precisely the same manner—as a serious threat to the security and long-term economic interests of the United States. These individuals, as well as supporters of conservation-oriented import reduction strategies, have pointed to its large expenditures during the Desert Storm campaign in the Persian Gulf as one cost of U.S. oil import dependency.[64]

Will reducing U.S. oil imports cause an improvement in energy security if even the reduced level is a large portion of total supply? And, conversely, will allowing imports to increase adversely affect security? After all, the United States will remain vulnerable to economic and military disruptions associated with Persian Gulf instability whether it is importing 30 percent of its oil or 70 percent, because any price increases attributable to that instability will affect all world oil supplies simultaneously and because U.S. agreements with its allies require sharing the effects of any widespread shortages.

It does matter to U.S. energy security whether import levels are lowered or raised. Lower imports would reduce pressures on worldwide oil supply, at least for a time, lowering the probability of a disruption in supplies and/or a rapid price increase. Also, higher oil prices would likely damage a U.S. economy importing 70 percent of its oil more than an economy importing 30 percent, because more of the added energy expenditures

64 Critics of this viewpoint would point out that attributing to U.S. oil vulnerability all costs of actions such as those Of Desert Storm ignores the other geopolitical considerations at stake, including a desire to protect our European allies and U.S. recognition of the long-term danger to the region of allowing a dictatorial regime to swallow its neighbor and gain access to the enormous wealth of the Kuwaiti oil fields (and the weapons purchases and development this wealth would allow).

would be recycled into the U.S. economy in the latter case. Further, to the extent that lower imports were caused by lower oil consumption-and conservation would yield this result—the effects of a rapid price increase would be reduced simply because the economy would be faced with paying for fewer barrels of higher-priced oil (or oil equivalent). Finally, if a percentage of U.S. highway travel relied on fuels whose prices were somewhat buffered from world oil prices, which is possible under certain circumstances,[65] the economic impact of an oil price shock would be still less.

The two different import levels may also differ in the degree to which the U.S. economy could quickly reduce its oil use to compensate for a shortage. Ironically, an economy with higher imports and oil use, though more vulnerable to damage from an oil shock, may have more options to quickly reduce its oil use; the more oil-efficient economy may already have undertaken many of the available options before a shock occurred.

Extent of the Security Threat

There is little doubt that an oil security threat to the United States still exists. There are four basic elements to this threat—the dependence of the U.S. transportation sector on petroleum: the limited U.S. potential to increase oil production; the preponderance of oil reserves in the Middle East/Persian Gulf; and the basic political instability and considerable hostility to the United States existing there. At least two (transport dependence and limited U.S. production potential) are as true today as they were in the early 1970s at the time of the Arab oil boycott.

In fact, in some ways these elements have grown more severe. For example, during 1973-92. the transportation sector's share of total U.S. petroleum use grew from 52 to 64 percent. This is particularly important because the sector's prospects for fuel switching in an emergency are virtually zero. In addition, the boom-and-bust oil price cycle of the postboycott period, and especial] y the price drop of 1985-86, created a wariness in the oil industry that would substantially delay any major boost in U.S. drilling activity in response to another price surge. With the passage of time, the industry's infrastructure, including skilled labor, that would be needed for a drilling rebound has been eroded. Further, environmental restrictions have placed much offshore oil off limits to drilling.

Despite the continuation of basic security problems outlined above, an examination of differences between the U.S. and world energy situation in the 1970s and the situation today shows some important positive changes:[67]

- the existence of the Strategic Petroleum Reserve and increased levels of strategic storage in Europe and Japan;
- increased diversification of world oil production since the 1970s:
- the end of U.S. price controls, allowing quicker market adjustment to price and supply swings:
- the advent of the spot market and futures market, making oil trade more flexible;
- the increasing interdependence of the world economy, particularly the major investments of the Organization of Petroleum Exporting Countries (OPEC) in the economics of the Western oil-importing nations and, especially, their oil-refining and marketing sectors;
- reduction or elimination of the large cash reserves of Persian Gulf exporters, reducing their ability to absorb the financial losses associated with an embargo;

[65] For example, if feedstocks for producing the fuel had no other uses that might compete with oil, and if the vehicles using this fuel were dedicated rather than flexible fuel.

[66] U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1992*, DOE/EIA-0384(92) (Washington, DC: June 1993), table 5.11.

[67] For a more detailed discussion of shifts in world oil markets, see U.S. General Accounting Office, *Energy Security: An Overview of Changes in the World Oil Market*, GAO/RCED-88-170 (Washington, DC: August 1988).

- a lessening of the strategic importance of the Gulf of Hormuz due to diversification of transport routes out of the Gulf;
- the growing importance of natural gas and its substitutability for oil in key markets;
- political changes in the Eastern Bloc nations and the resulting lowering of tensions between East and West (although this is counterbalanced somewhat by growing tensions among nations in the former Eastern Bloc);
- new prospects for developing oil resources in the Far East (e.g., Vietnam) and the former Soviet Union;
- demonstration in the North Sea that new technology, cost-cutting design and management, and more sympathetic tax and royalty structures can increase enormously the resource and production potential of areas once thought "mature"; and
- a general lessening in Arab hostility to the United States, associated in part with U.S. sponsorship of Arab-Israeli peace negotiations and its role in liberating Kuwait. Another positive sign in the area is the decline of Mideast-connected international terrorism. A potential counterbalance is the growing tension between the religious and secular communities in the Mideast.

This variety of changes in world oil markets can be summarized as a general shift to more flexible and responsive markets, with closer economic ties between oil producers and users, improved overall supply prospects, and improved capability for effective *short-term* responses to market disruptions.

The overall effect of this complex series of changes and adjustments since the early 1970s has likely been a net improvement in U.S. and world energy security, at least for the short term. A substantial disruption of oil markets is probably less likely now than it was then, and the industrial nations appear better equipped to handle a disruption if one were to occur, especially over the short term. Further, the recent political changes in the Soviet Union and its Eastern Bloc neighbors are redefining basic perceptions about the nature of U.S. national security problems. Nevertheless, it remains true now, as it did then, that the lion's share of the world's oil reserves lies in the Persian Gulf nations, that these nations have most of the world's excess oil production capacity, that they remain politically shaky, and that there exist groups extremely hostile to the United States even in those nations we consider our friends. As long as this is true and as long as a sharp price shock would be disruptive to the U.S. economy (although the magnitude of the disruption is in dispute), policy makers must still count the effects on energy security as an important factor in judging proposed energy policy measures. However, the relegation of energy security from the "number one energy issue" status that it held in the 1970s to the somewhat lower status that it has today, seems to be a reasonable response to both a reduced security risk and an increased concern about environmental issues.

Also, policy makers should recognize that the U.S. balance between domestic and imported energy is enviable compared with most of the developed world. Whereas U.S. oil imports for 1992 were about 41 percent of oil consumption (and less than 20 percent of total energy consumption), the European OECD nations imported about two-thirds of their oil, and Japan all of its oil and most of its energy. However, this difference might be interpreted in the opposite fashion: that it illustrates further the U.S. dilemma because of our close economic and military ties to the OECD nations. Further, the U.S. advantage in its overall reliance on domestic energy sources is partially canceled by its relatively higher level of oil use per unit of gross national product (GNP) and per capita. As discussed in chapter 3, for example, both the Japanese and the Europeans use far less oil per capita than the United States for passenger transport, and far less per unit of GNP for freight transport. This means that oil price increases driven by market disruption would tend to hurt the American economy more than either the European or the Japanese economies.

Impact of Conservation on Security

In examining the impacts of transportation conservation initiatives on U.S. energy security, it is important to recognize that different categories of initiatives will have different impacts. It is worthwhile to examine separately three categories of conservation initiatives:

1. improvement in the long-term technical efficiency of transport;
2. changes in behavior that reduce energy use (e.g., in load factor, driving patterns, and maintenance); and
3. switching from oil-based to alternative fuels.

Improvements in technical efficiency change the capital and management structure of transportation (e.g., by improving the basic fuel economy of vehicles, by smoothing traffic flow with improved signaling, or by using computer-aided scheduling and management to improve load factors in freight hauling). Generally, these improvements occur slowly and require substantial capital investment over time. Thus, the improvements are not available to serve as a short-term response to an oil shock, and their implementation does not "use up" a potential strategy for managing such a shock. Therefore, cost-effective improvements in energy-efficiency technology are unambiguously beneficial to U.S. energy security.

Changes in behavior—such as improving engine maintenance in automobiles, forming carpools, inflating tires properly, using better trip planning—reduce oil use at low cost and will reduce the immediate economic shock of an oil disruption. These measures yield environmental and long-term economic benefits. Ironically. however, their implementation well in advance of a price shock will reduce somewhat the ability of the economy to respond to a disruption. Although deliberately leaving some "slack" in oil consumption is by no means recommended-it almost certainly has fewer benefits than costs--conservation-oriented changes in short-term behavior may have smaller energy security benefits than would improvements in technical efficiency.

The development of alternative transportation fuels can have a positive effect on energy security by diversifying supply sources or getting supplies from domestic or more secure foreign sources, easing pressure on oil supplies through reduced demand for gasoline, and reducing the impact of an oil price shock. The magnitude of the effect will depend on the feedstock used for the fuel, the volume of alternative fuel use, the selection of dedicated vehicles or flexible fuel vehicles, and so forth. The magnitude of any subsidies is important as well. Large subsidies of "secure" energy sources can backfire because the subsidies themselves may harm U.S. economic efficiency and competitiveness. Policy makers must carefully balance the value of establishing alternatives to foreign oil imports against the market distortions of large subsidies.

Although the security benefits of some fuels are indisputable, analysts disagree about others. Fuels such as electricity,[68] hydrogen, and ethanol are likely to be produced domestically and thus unambiguously advantageous to energy security (again, *if* they can be produced cheaply enough), although ethanol current dependence on intensive corn production,[69] which may suffer on occasion from drought, may make it less secure than the others. Natural gas would likely rely on domestic supplies or gas pipelined from Canada or Mexico, although supply requirements above a few trillion cubic feet per year could strain these sources--especially if gas usage for other sectors continues to increase. With secure sources, natural gas use should be beneficial to energy security.

[68] Strictly speaking, electricity is not a fuel, but it is convenient to categorize it as such in this discussion.

[69] Continuing advances in producing ethanol from wood, wood waste, and wastepaper could break this dependence.

However, natural gas competes with both residual oil and middle distillate in commercial and industrial markets. Higher gas prices, which could result from large-scale transportation use, would lead to some shift from gas to oil in these markets, thereby increasing oil imports. Thus, the oil "saved" by shifting to gas in vehicles would not reduce imports on a one-for-one basis.

Methanol could be produced domestically in substantial quantities,[70] although it is also quite possible that a large portion of methanol supplies would be imported from countries with large gas reserves. In the latter case, methanol effect on energy security will depend on which countries enter the market, the type of financial arrangements made between producers and suppliers, the worldwide price relationship between natural gas and oil (i. e., will a large oil price rise automatically raise gas—and methanol—prices?), and other factors. Because two-thirds of the world's gas reserves reside in the Middle East and the Eastern Bloc, some analysts deny that the United States would receive any security benefit from turning to methanol. The Nation *can* derive a security benefit even if much of the methanol were imported, because methanol use will reduce pressures on world oil supplies; also, strategies such as establishing long-term trade pacts with secure methanol sources could enhance the potential benefits.

Positive effects on energy security of alternative fuels use could be reduced or canceled if automakers claim corporate average fuel economy (CAFE) credits for the alternatively fueled vehicles they manufacture and reduce their actual fleet fuel economy below the levels they would have attained had the credits not been available (see chapter 5, section on alternative fuels) .7] The likelihood that CAFE credits will be used in this fashion is in dispute, but the probability that they will be used to depress actual fleet fuel economy will increase steeply if CAFE standards are raised without a shift in the relative indifference to fuel economy currently demonstrated by car purchasers,

There is one energy security issue that cuts across the various categories of conservation measures. A large reduction in U.S. oil demand, whatever the cause, could serve to reduce world oil prices. Lower prices would boost the United States and world economies but would also depress U.S. oil production which would then have to be made up with imported oil. The effect would be to reduce the drop in oil imports that would otherwise be expected, thus reducing the net benefit to energy security. There is considerable uncertainty about the sensitivity y of world oil price to demand, but it is likely that a drop of a few million barrels per day (mmbd) would be needed to sustain a long-term drop in world oil prices.[72]

Energy Security Costs

Some analysts have attempted to measure in dollar terms the energy security costs of using imported oil and thus the energy security *value* of re-

[70] The economics of conventional methanol production depend substantially on the resource cost, interest rates, distance from markets, and availability of support infrastructure. Current low gas costs and interest rates in the United States, coupled with U.S. superiority with regard to availability of infrastructure and closeness to markets, imply that domestically produced methanol can be competitive with methanol produced from inexpensive remote gas and shipped to the United States. The longevity of these favorable conditions is unclear, however. An alternative mode of production—methanol as a coproduct of steel production—might also serve to supply competitive domestic methanol to U.S. markets.

[71] Automakers producing an alternatively fueled vehicle are allowed to record that vehicle's fuel economy according to the amount of o11-based fuel consumed. In other words, a vehicle consuming only a blend of 90-percent methanol and 10-percent gasoline would have a recorded fuel economy approximately 1() times as high as its counterpart vehicle consuming gasoline {rely. By manufacturing large numbers of such vehicles, automakers would artificially raise their fleet fuel economies, thus giving them "headroom" to reduce the fuel economy of the remainder of their fleets.

[72] One Department of Energy model projects a $0.93 per barrel drop in w (mid oil prices in response to a 2.5-mmbd reduction in U.S. demand. Philip Patterson, U.S. Department of Energy, personal communication, 1993.

ducing oil imports. (Note that these costs do not necessarily represent the total net security value of reducing imports, because the measures taken may have their own security costs. This is especially true for alternative fuels requiring importation of the fuels themselves or their feedstocks.) The types of costs associated with energy security include the following:

- *Risks of an oil disruption.* Most of the costs to the economy of occasional disruptions to world oil supply—lost productivity, inflation, and so forth—are not included in the price of oil, even though such disruptions have happened three times in the past and almost certainly will occur again. To the extent that significant reductions in oil use and oil imports would lower these costs,[73] their inclusion in oil prices and the incentive to reduce consumption provided by their inclusion corresponds to an actual benefit to the U.S. economy. The Congressional Research Service (CRS) has estimated costs for the disruption risk of $6 billion to $9 billion, or 5 to 7 cents per gallon of motor fuel, after accounting for the protection offered by the SPR, greater private reserves, and the advent of the oil futures market.[74] Other analyses offer alternative estimates of disruption costs ranging from near zero to levels considerably higher than the CRS estimates.[75]
- *Market power associated with oil use reductions.* Theoretically, a substantial reduction in U.S. oil use could create world excess oil production capacity and reduce world oil prices, which would benefit the U.S. economy as well as that of oil importers worldwide. Because individual oil users would not consider such benefits-their actions cannot alone have any effect on world prices—this potential benefit of oil use reduction will be lost unless it is directly incorporated into oil prices or indirectly accounted for by regulatory controls on consumption. Controversy about the magnitude of this benefit of use reduction (cost of consumption) stems primarily from disagreement about the magnitude of reduction necessary to have any effect on price, uncertainty about the potential for OPEC to respond successfully to a drop in oil demand (by decreasing production), and how long the benefit would last. CRS's estimate of this so-called monopsony component of an oil price premium is $21 billion to $24 billion, or 17 to 20 cents per gallon.[76]
- *National security expenditures.* The United States spends large amounts on military expenditures related to oil use, for example, rapid deployment forces that can be targeted to Middle East flashpoints. Desert Storm cost more than $61 billion, although much of this was paid by U.S. allies.[77] Allocation of these costs to actual oil costs is highly uncertain, however. In particular, U.S. military expenditures are linked to complex geopolitical considerations wherein oil security is only one of several elements; and the extent to which U.S. oil use drives military expenditures is dependent on administration and congressional *perceptions* of oil security, which may be different from reality. Further, the U.S. military stake in the Middle East is

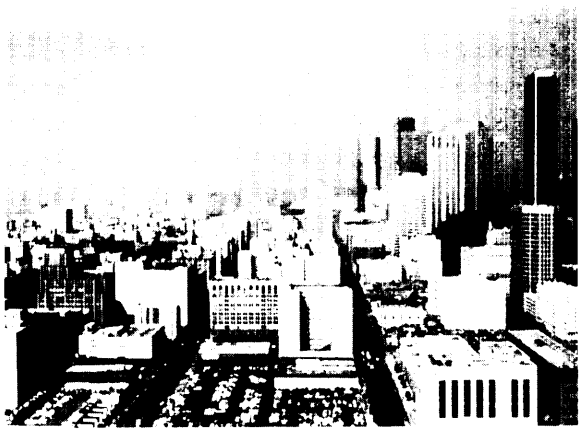
[73] By easing oil markets and thus reducing the *risk* of a disruption occurring, and by reducing the volume of capital exported from the U.S. economy to the exporting nations in the event of a disruption.

[74] Congressional Research Service, Environment and Natural Resources Policy Division, "The External Costs of Oil Used in Transportation," June 3, 1992.

[75] See for example D.R. Bohi, *Energy Price Shocks and Macroeconomic Performance* (Washington, DC: Resources for the Future, 1989) for a rationale for very low estimated disruption costs. Greene and Leiby (D.L. Greene and P.N. Leiby, *The Social Costs to the U.S. of Monopolization of the World Oil Market, 1972-1991*, ORNL-6744 (Oak Ridge, TN: Oak Ridge National Laboratory, January 1993) estimate disruption costs (macroeconomic adjustment costs) of $0.8 trillion to $1.3 trillion (1990 dollars) over the 20-year period oil used. Although this value is a 20-year average cost and does not reflect current conditions, it still appears to imply a higher disruption cost than the CRS value.

[76] Ibid.

[77] Ibid.



SCAQMD

Los Angeles has the Nations most severe ozone pollution problem Urban air pollution remains a crucial national problem more then two decades after passage of the Clean Air Act

complicated by U.S. obligations to its allies in the event of an oil disruption; these obligations may limit the reductions in military costs that might otherwise be expected to follow U.S. reductions in oil use. Alternative estimates of annual oil-related expenditures for defense of the Middle East-Persian Gulf region range from less than $0.5 billion annually to $50 billion and higher.[78] Alternative ways of allocating these costs yield a range of 1.5 to 30 cents per gallon.

OZONE POLLUTION AND TRANSPORTATION[79]

Although past transportation energy conservation initiatives have aimed primarily at reducing oil use or at relieving transportation service problems such as congestion, the motivation for many conservation initiatives during the past few years has been the relief of urban air pollution problems, particularly ozone-related problems. Today, more than two decades after the Clean Air Act original passage, about 100 urban areas (depending on weather conditions) still violate the National Ambient Air Quality Standard for ozone.[80]

Since 1970, Federal and State governments have maintained separate but interacting roles to handle ozone control, with the Environmental Protection Agency (EPA) setting nationally uniform ambient air quality standards and New Source Performance Standards,[81] and the States, with EPA's help and oversight, developing and enforcing detailed implementation plans[82] to attain the air quality standards. Based on ozone's known health effects, the standard is currently set at a peak, 1 -hour average ozone concentration of 0.12 part per million (ppm). Any area experiencing concentrations exceeding the standard more than once a year, on average, is declared a nonattainment area. EPA updates the nonattainment list annually, as data become available. The list in 1991 included cities housing about 140 million people.[83]

Why Control Ozone?

The O. 12-ppm national standard for ozone derives from solid evidence of the health effects of short-term exposure above that level. Excessive ozone is harmful to people. Even healthy adults and children can experience coughing, painful breathing, and temporary loss of some lung function after

[78] Ibid.

[79] Except where otherwise referenced, the information in this section is based on U.S. Congress, Office of Technology Assessment, *Catching Our Breath: Next Steps for Reducing Urban Ozone*, OTA-O-412 (Washington, DC: U.S. Government Printing Office, July 1989).

[80] U.S. Environmental Protection Agency, *National Air Quality and Emissions Trends Report, 1991*, 450-R-92-001 (Washington, DC: October 1992).

[81] That is, emission and emission control technology standards for large new individual sources of air pollution (e.g., a new powerplant or refinery).

[82] Which include emission standards for both existing emission sources and new sources not subject to Federal standards, regulations to control development in especially polluted areas, and so forth.

[83] U.S. Environmental Protection Agency, op. cit., footnote 80.

about an hour or two of exercise at peak concentrations found in nonattainment cities.

Experts are unsure whether the current standard adequately protects people who are exposed for long periods or at high exercise levels. Several studies over the past 5 years have shown temporary loss of some lung function after an hour or two of exposure at concentrations between 0.12 and 0.16 ppm, among moderately to heavily exercising children and adults. And despite the current standard's emphasis on a 1 -hour peak, real-life exposures to near-daily maximum levels can last much longer; ozone levels can stay high from midmorning through late afternoon. With exposure during 6 hours of heavy exercise, temporary loss of some lung function can appear with ozone levels as low as 0.08 ppm.

Potentially more troubling and less well-understood are the effects of long-term, chronic exposure to summertime ozone concentrations found in many cities. Regular outdoor work or play during the hot, sunny summer months in the most polluted cities might, some medical experts believe, cause biochemical and structural changes in the lung, paving the way for chronic respiratory disease. To date, however, evidence of a possible connection between irreversible lung damage and repeated exposure to summertime ozone levels remains inconclusive.

Aside from damage to human health, ozone pollution damages the natural and managed environments. In particular, clear evidence shows that ozone damages economically, ecologically, and aesthetically important plants. When exposed to ozone, major annual crops produce reduced yields. Some tree species suffer injury to needles or leaves, and lowered productivity; in severe cases, individual trees can die. Important tree species are seriously affected in large areas of the country. In the most heavily affected forested areas, such as the San Bernardino National Forest in California, ozone has begun altering the natural ecological balance of species.

Whether or not the current standard is adequate, many areas of the country have failed to meet it. About half of all Americans live in areas that exceed the standard at least once a year. In 1991,74 of 98 EPA-designated nonattainment areas were classified either as marginal or moderate, 14 were classified as serious, nine as severe, and one (Los Angeles) as extreme.[84]

Ozone and Its Precursors

Ozone is produced when its precursors, volatile organic compounds (VOCs) and nitrogen oxides (NO_x), react in the presence of sunlight. VOCs, which include hundreds of specific compounds, come from both natural and human-made sources, the latter including automobile and truck exhaust, evaporation of solvents and gasoline, chemical manufacturing, and petroleum refining. In most urban areas, such human-made sources account for the great majority of VOC emissions, but in the summer in some regions, natural vegetation may produce an almost equal quantity. NO_x arises primarily from fossil fuel combustion. Major sources include highway vehicles, and utility and industrial boilers.

Ozone control efforts have traditionally focused on reducing local VOC emissions, partly because the relevant technologies were thought to be cheaper and more readily available, In some areas, however, controlling NO_x is more important than controlling VOCs. However, *under some conditions at some locations,* reducing NO_x can be counterproductive because of the peculiarities of ozone formation chemistry.[85]

Local controls on VOC emissions cannot completely solve the Nation's ozone problem. In many places, even those with good control of local emissions, reducing ozone is complicated by the "transport" of pollutants as ozone or precursors

84 Ibid.

85 Although NO_x is an ozone precursor, it also can destroy ozone when NO_x/VOC ratios are high.

originating elsewhere are carried in by the wind. "Plumes" of elevated ozone have been tracked 100 miles or more downwind of some cities: the Greater New York area's plume, for example, can extend all the way to Boston. More than half of the metropolitan areas that failed to attain the ozone standard between 1983 and 1985 lie within 100 miles downwind of other nonattainment cities. In such cases, VOC (and sometimes NO_x) reductions in the upwind cities could probably improve the air quality of their downwind neighbors. Indeed, reductions in certain areas that are themselves already meeting the standard might also aid certain downwind nonattainment areas.

The significance of transported pollutants varies substantially from region to region and day to day. During severe pollution episodes lasting for several days, for example, industrial or urban NO_x or ozone pollution can contribute to high ozone levels hundreds of miles away. In certain heavily populated parts of the country, pollution transport is a significant and very complex problem. The Northeast Corridor, from Maine to Virginia, contains 21 nonattainment areas in close proximity; California contains eight; the Gulf Coast of Texas and Louisiana, seven; and the Lake Michigan area, five.

Controlling Volatile Organic Compounds

Since 1970, reducing VOC emissions has been the backbone of U.S. ozone control strategy, and the Nation has made substantial progress, at least in slowing further degradation from preexisting conditions. According to EPA estimates, VOC emissions were reduced by 13 percent during 1982-91;[86] without existing controls, they would have grown considerably during this period. Despite this progress, however, large areas of the country have missed each of several 5- and 10-year deadlines set by Congress-the original deadline of 1975, and again in 1982 and 1987.

In 1982, highway vehicles accounted for about 45 percent of all VOC emissions; in 1991, their share had been reduced to about 35 percent[87] through implementation of tighter emission controls, retirement of older vehicles, and institution of limits on gasoline volatility.

If we are willing to use and pay for currently available technology, we can make significant advances over the next 5 to 10 years, achieving about two-thirds of the emissions reductions in nonattainment areas needed to meet air quality standards. This should bring about half of current nonattainment areas into compliance. However, by the year 2000, the entire Nation cannot reach the goal that Congress established in 1970. In the worst areas, even the most costly and stringent of available measures will not lower emission levels sufficiently to meet the standard. Achieving that goal is a long-range project, well beyond the 5- and 10-year horizons of existing law. It will require both new technologies and lifestyle changes in the most affected communities, including changes in transportation, work, and housing patterns.

To meet ozone standards in all cities, new, nontraditional controls, with uncertain costs, must be used. One of these controls involves significantly reducing the use of motor vehicles, especially private cars. Although technologically simple, this is politically difficult. The 1977 amendments to the Clean Air Act required urban areas to implement whatever measures were needed to attain the ozone and carbon monoxide standards, including transportation control measures (TCMs). Experience shows, though, that TCMs require considerable local initiative and political will because they aim to change the everyday habits and private decisions of hundreds of thousands of people. Involuntary TCMs have proven politically infeasible, and voluntary programs difficult to sustain. Success requires long lead times, priority in urban transportation and land use planning, a high degree of public support and participation, and in

[86] U.S. Environmental Protection Agency, op. cit., footnote 80.

[87] Ibid.

some cases such as mass transit development, major capital expenditures. Possible tactics include requiring staggered work hours; encouraging carpools through inducements such as priority parking places, dedicated highway lanes, and reduced tolls; constructing attractive and economical mass transit systems; limiting available parking places; and encouraging employers to locate closer to residential areas, which could cut the distances workers have to travel.

As with the other external costs of transportation energy use, estimates of the costs of ozone-related air quality damage to public health and welfare are controversial because of both scientific disagreements and differences in value judgments. Calculating these costs means constructing a credible inventory of transportation emission sources, estimating resulting pollution concentrations in ambient air, transforming these concentrations into damage estimates, and computing the monetary costs of the estimated damages—and none of these steps is without controversy. For example, even the emission inventory, presumably the most easily measured of the four steps, is subject to considerable error because the available emission tests do not accurately replicate actual driving conditions (e.g., tests performed during inspection and maintenance programs miss the cold start, which is the critical period for emissions and, because they do not use a dynamometer, do not capture the true effects of acceleration).

OTA has investigated the monetary costs of transportation-related ozone damage, focusing primarily on health impacts and damage to commercial crops and forests. The quantifiable health impacts of reductions in ozone concentrations involve primarily the reduction in numerous episodes of respiratory discomfort--coughing, chest pain, shortness of breath—among many of the over 100 million persons living in nonattainment areas. Meeting the ozone standard everywhere would avoid several hundred million of these episodes each year, with some people in the worst areas experiencing dozens fewer incidents of respiratory symptoms annually. About 8 million to 50 million person-days per year of restricted activity may be eliminated; these are days when someone feels ill enough to limit the day activities, if not necessarily to stay in bed or home from work. Most of the benefit would be concentrated in high ozone areas such as southern California and the Northeast corridor cities. The economic value of eliminating these short-term effects might be about $0.5 billion to $4 billion a year, a large fraction of which will be transportation-related benefits,[88] with most benefits concentrated in high-ozone areas such as southern California and the Northeast Corridor. *Although the value of the decreased risk of long-term, chronic effects of ozone exposure cannot be estimated, these potential effects remain a strong concern.*

OTA has also examined the potential effects on agriculture of reduced ozone concentrations. These estimates are complicated by the current inability to reliably predict the impact that VOC and NO_x control measures would have on ozone concentrations in rural areas (partly because current ozone concentrations in areas where crops are grown are not accurately known) and uncertainty about how farmers will respond to improved growing conditions in their planting operations. For a reduction in rural ozone of 50 percent of the difference between current levels and background concentrations, agricultural benefits are estimated to be $1.01 billion to $1.91 billion annually, primarily from improved yields of corn, soybeans, wheat, and cotton. with most benefits occurring in California, the South, and the Northeast.[89] With the likelihood that nontransportation controls would be very limited in rural areas, much of this

[88] If 40 percent of the ozone reduction is caused by reductions in transportation emissions, transportation-related benefits would be about $0.2 billion to $1.6 billion per year. However, the 40 percent value is simply speculation.

[89] Based on two models using different methodologies and assumptions. See U.S. Congress, op. cit., footnote 20.

benefit might be attributed to transportation controls.

The Congressional Research Service estimates transportation-related ozone damage to forests of $0.1 billion per year, incorporating both damage to recreational values and damage to the forest materials resource.[90]

OTHER EXTERNALITIES

Aside from ozone pollution, energy security, and greenhouse warming, other transportation externalities are important and should be considered in evaluating alternative transportation policies or full cost accounting. These include:

- other air pollution damages;
- aesthetic losses from facilities or vehicles;
- noise pollution;
- vibration damage, especially from highways and railroads;
- water pollution, especially from roadway runoff—also, loss of groundwater recharge and absorptive capacity for flood prevention from highway land use;
- accident impacts on nonusers or on society (e.g., lost productivity) that are not compensated by user insurance or other payments;
- ecosystem losses from highways, airports, etc.; and
- effects on energy efficiency, economic vitality, open space, ecosystem protection, and other values caused by the patterns of land use associated with transportation choices.

Although attempts have been made to quantify these costs,[91] they remain uncertain for reasons of inadequate data on the magnitude of the impacts, disagreement about their monetary valuation, and ambiguity about where to draw the boundaries to separate externalities from impacts borne by users. Further, with air pollution excepted, these externalities are not tied as directly to oil use, or energy use, as the initial three (ozone pollution, energy security, and greenhouse warming). Although reducing energy use by reducing travel demand or shifting modes will tend to reduce (or at least change) these externalities, improving technical efficiency (e.g., by improving auto fuel economy) will not; levels of accidents, road capacity requirements, aesthetic losses, and other externalities will be essential y unchanged despite the reduction in oil use.

Other Air Pollutants

Aside from ozone, key transportation-related air pollution problems include emissions of carbon monoxide (CO) and fine particulate matter.

Excessive levels of CO are associated with aggravation of angina pectoris in individuals with heart disease, occasional deaths from suicide and faulty vehicle exhaust systems, and widespread cases of headache and other low-level health effects. About 70 percent of national emissions of CO are vehicle exhaust emissions.[92]

Particulate air pollution—solid particles and liquid droplets—has been associated with a variety of adverse health effects; elevated particulate levels can lead to respiratory symptoms such as cough, shortness of breath, and asthma attacks and have been associated with increased rates of hospitalization, restricted activity due to illness, and chronic respiratory disease. Of greatest concern are fine particulate, those smaller than 10 mi-

90 Congressional Research Service, op. cit., footnote 74.

91 For example, M.E. Hanson, "Automobile Subsidies and Land Use: Estimates and Policy Responses," *Journal of the American Planning Association*, vol. 58, No. 1, 1992, pp. 60-71; B. Ketcham, "Making Transportation a National priority," paper presented at panel discussion on "Transportation as a Matter of Choice," Snowmass, CO, Oct. 6, 1991; J.J. MacKenzie et al., *The Going Rate: What It Really Costs to Drive* (Washington, DC: World Resources Institute, 1992) all discussed in M.E. Hanson, "Results of Literature Survey and Summary of Findings: The Nature and Magnitude of Social Costs of Urban Roadway Use," paper prepared for the U.S. Department of Transportation, Federal Highway Administration, 1992.

92 U.S. Environmental Protection Agency, *National Air Quality and Emissions Trends Report, 1991*, 450-R-92-001 (Washington, DC: October 1992).

crons that can evade the normal defense mechanisms of the human respiratory system, penetrating deep into the lungs. Epidemiologic studies have shown a statistical association between high levels of fine particulate and premature deaths.[93] Key problem areas for highway vehicles include carbon particles from diesel-powered vehicles, particulate formed from hydrocarbon emissions, sulfate particles from diesel and gasoline-powered vehicles, and fine particulate associated with tire wear. Because requirements for diesel fuel and reformulated gasoline include reduced sulfur levels, fine particulate problems associated with sulfate emissions from vehicles should decrease in the future.

Land Use Impacts

As discussed in chapter 5, transportation choices and land use are linked by the varying direct land requirements of alternative transportation modes, the minimum population density requirements of mass transportation modes, and the different types of mobility—and thus the differing levels of practicality for certain locational choices--offered by alternative modes. Although the linkages between land use and transportation are not absolute, urban areas whose transport systems are based primarily on automobiles tend to be far less dense than areas relying primarily on mass transit, with more emphasis on single-family housing than on apartments, less likelihood of walking access to services, and so forth. Automobile-based land uses generally are more energy-intensive than those based on mass transportation, even if direct transportation energy costs are disregarded, because of the higher heating and cooling costs of single-family residences and other factors, Although these costs are not externalities-they are borne directly by "users," if all residents of such developments are at least indirectly users of the dominant transportation system—some or all of the external costs associated with increased nontransport energy use should be charged to the transportation system choice.

Aside from higher energy costs, the type of dispersed land use and economic development associated with automobile-oriented transportation systems has other costs that may be considered, at least in part, transportation externalities. One such cost is disinvestment in downtown areas as retail stores relocate to suburban malls. upwardly mobile families move to the suburbs. and businesses move to office parks; with such trends. social services become more difficult to deliver, job opportunities for inner-city residents shrink. and city neighborhoods decline.[94]

Accidents

Accidental deaths and injuries associated with different transportation modes represent large external costs and subsidies to the transportation system because of the nature of the damages and the way society pays for them, and because a significant percentage (about 17 percent[95]) of the damages occur to persons who are only peripheral users of the modes (e.g., pedestrians and bicyclists). According to a recent FHWA-sponsored study, highway accidents caused $358 billion in damages in 1988.[96] Most of the physical damage occurs to drivers and passengers, but the monetary component of this damage (property damage, medical expenses. ambulance costs. etc.) is paid for only part] y out of auto insurance, as discussed above, and thus there is a substantial subsidy to

[93] D.W. Dockery et al., "An Association Between Air Pollution and Mortality in Six U.S. Cities," *New England Journal of Medicine*, vol. 329, No. 24, Dec. 9, 1993.

[94] L.S. Bourne, "'Self-Fulfilling Prophecies? Decentralization, Inner City Decline, and the Quality of Urban Life,'" *American Planning Association Journal*, autumn 1992, pp. 509-513.

[95] National Safety Council, *Accident Facts, 1990 Edition* (Chicago, IL: 1990), cited in MacKenzie et al., op. cit., footnote 91.

[96] Urban Institute, *The Costs of Highway Crashes*, FHWA-RD-91-055 (Washington, DC: U.S. Department of Transportation, Federal Highway Administration, June 1991), cited in MacKenzie et al., op. cit., footnote 91.

the transportation system. The negative effect on society and the economy of lost productivity due to accidents, especially where accident victims have skills that are not easily replaced, may represent a large externality; depending on where analytic boundaries are drawn, so may the component of damages to "peripheral users" that is not paid by auto insurance or directly by the responsible drivers.

Noise and Vibration

Noise and vibration from highway vehicles, railroads, and airplanes strongly affect quality of life, reduce property values, and in the case of vibration, do structural damage. People and property alongside rights of way or under flight paths are the most affected. Data to estimate vibration damage are inadequate. Examination of changes in property values with decibel levels can lead to highway noise damages estimated at several billion dollars per year, primarily due to heavy trucks.[97]

Ecosystem Losses

Both the direct land requirements of transport systems and the requirements of the land uses they support have significant impacts on ecosystems. The value of these losses is controversial, particularly the loss of prime farmland around cities, because there is severe disagreement about the adequacy of U.S. cropland resources for future needs. If long-term annual increases in crop yields continue at historic rates, the effect on U.S. food production capability of cropland losses from roadbuilding and the urban sprawl that our auto-oriented system supports will be small or, from a practical standpoint, nonexistent. However, many in the environmental community believe that increases in crop yields cannot continue, that we are reaching the natural limits of an agricultural system based on high levels of chemical input, and that losing high-quality cropland to urban and suburban development will force agriculture onto ever more marginal land and soon begin to limit production. This is an extremely controversial issue; there is nothing in the statistical record to indicate an imminent slowdown in yield increases, and many in the agricultural community look to genetic engineering to provide another long-term round of yield increases, but data on erosion rates (which have been higher than soil replacement rates for years), pesticide usage and growing immunity problems, and other factors cause great concern.

[97] MacKenzie et al., op. cit., footnote 91. Decibel levels are correlated with type of roadway, amount and nature of traffic, and air pollution levels, all of which can affect property values (e.g., the safety, aesthetic, pollution, and congestion impacts of a roadway may vary in step with decibel levels and impact property values in the same direction). This type of collinearity makes it quite difficult to separate the effect of a single variable and makes quantitative estimates somewhat suspect.