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PAPER THREE

THE ROADS AREN'T FREE: ESTIMATING THE FULL SOCIAL COST OF DRIVING AND THE EFFECTS OF ACCURATE PRICING

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I. INTRODUCTION

Since the Second World War, automobile traffic has increased enormously, and per capita ridership on public transit has declined. This change in local transportation patterns has given households much greater mobility and freedom than in the past. But it has also created a number of problems. The rise of the car culture has caused environmental, social, economic, and political damage. The reason is quite simple: private vehicles have not had to pay their own way.

A revenue-neutral tax shift that raised the price of driving and other socially damaging behavior while lowering taxes on productive effort would have important impacts on these problems. Such a policy would, for example, undoubtedly affect urban transportation choices. It would influence how much people drive and the kinds of cars they use, where they choose to live in relation to their jobs, and their willingness to use public transit. The purpose of this paper is to explore these potential effects.

The Hidden Costs of Automobile Use

The reason for raising the price of driving as part of the tax shift is to offset, or internalize, some of the costs driving imposes on society. A cost involves the loss of real resources—time, energy, material, health, and so on—regardless of whether any money actually changes hands. A subsidy, on the other hand, exists whenever someone does not have to make payments in direct proportion to the marginal costs he or she imposes on society. Prices should convey information to consumers about the scarcity of the resources used in making a product or a service. If prices fail to reflect that scarcity, the product or service will be overconsumed. This overconsumption has occurred on a massive scale in the case of driving. Since drivers have not been required to pay the true marginal cost of operating a vehicle (that is, since driving is underpriced), private transportation has appeared to be cheaper than it really is. If the actual marginal cost of driving could be determined, it could be reflected in the prices motorists pay, thereby affecting transportation choices through market forces.

When people drive passenger vehicles, both private and social costs are involved. A private cost is one that involves only those directly involved in a transaction. A social cost is one that involves one or more third parties.

The costs of operating a vehicle (i.e., depreciation and maintenance), access to roads, and the protection of petroleum supplies could be deemed private costs. While the latter might seem to be public goods since the government generally provides for them, this is not really the case. A true public good or service is one for which the benefits are indivisible, so that none can benefit unless all benefit.[1] Private services that are paid for with public funds constitute one category of subsidy. Road access is a private good because, in principle, it would be possible for someone to build a road and charge for access to it—just as airlines and railroads charge for access to their facilities. The same is true of the costs of protecting the supply of petroleum that is used to fuel vehicles. In principle, the oil companies could privatize protection of their supply lines.

The cost of damage to other vehicles and the unseen costs of pollution and congestion—including economic loss—are social costs. The law currently requires motorists to internalize some of these costs by purchasing insurance to cover damage to other motorists and their vehicles. Pollution costs are also partially internalized by laws requiring that vehicles be designed in ways that limit emission of various air pollutants. These payments are not sufficient to offset all social costs, however.

When drivers do not bear the full costs of driving, they are receiving a subsidy—even if the government is not "paying" them anything. Many of these subsidies are implicit; that is, they amount to costs imposed on third parties that drivers do not pay directly. If those costs became visible, in the form of taxes or other mechanisms that raised the price of driving, such as auctioned permits for greenhouse-gas emissions or removal of existing subsidies to driving,[2] a variety of consequences could follow. For example, transit enthusiasts hope that charging a higher price for driving would encourage more people to ride buses, light-rail, or subways. Highway planners hope that it would reduce the amount of driving, thereby somewhat diminishing the problem of congestion. And environmentalists hope that more expensive driving would result in a lower contribution to global climate change, fewer emissions of air pollutants, and more livable cities.

The Nature of This Report (Purpose and Assumptions)

This report estimates the full social cost of driving above and beyond the amount motorists pay today. Specifically, it estimates the amount of a gasoline tax that would be needed to compensate for that social cost, and it projects the effects of the increased price of gasoline on vehicle use, fuel efficiency, urban form, transit use, carpooling, and telecommuting. This report does not deal with freight transportation or air transportation of passengers, but focuses exclusively on the effects of a gasoline tax on the use of light passenger vehicles.

Because the ideas presented herein would have far-reaching impacts that cannot be entirely foreseen, this report is not intended as a policy proposal. Any increase in the gasoline tax of the magnitude considered here would need to be phased in over time and adjusted as information about driver response became available. Estimates of changes in behavior have been calculated based on a ten-year time window; thus, assuming that personal incomes continue to grow throughout this period, the effects of the increase in gasoline prices will be somewhat diminished. The report contains no original estimates of social costs or price elasticities, nor does it attempt to determine the magnitude of price increase that would be politically acceptable.[3] Instead, it relies on conservative or midpoint estimates from sources with wide ranges of values for social costs.

Summary of Findings

The most significant finding of this report is that the social costs of driving amount to at least $184 billion per year. This is equivalent to $1.60 per gallon of gasoline (although a gasoline tax only imperfectly captures some of the social costs). The predominant effect of phasing in such an increased charge on gasoline would be to induce drivers to buy vehicles that are about three times as efficient as today's. In other words, after the cries of protest died down, Americans would set about taking advantage of the technology that could easily become available if the price incentives were right. More expensive gasoline would thus not force most people to drive less; rather, they would just drive more efficient vehicles.

For those who imagine that offsetting some of the social costs of driving through a gasoline tax would automatically reduce driving, such results will be disappointing. Higher priced gasoline would slightly reduce the number of miles driven in the short run; in the long run, however, families would buy more efficient vehicles, incomes would rise, and the income effect would outweigh the effect of higher fuel prices. There would be a minor shift to carpooling and an even smaller shift to transit ridership. The evidence regarding the effects of higher fuel prices on urban form is mixed, but—barring other changes in public policy—most suburban residents would not choose to live much closer to downtown if the price of gasoline rises.[4]

No single policy measure would be able to recoup the full social costs of driving. An added charge for gasoline would require motorists to pay those costs associated with fuel consumption and road use. Other costs—such as noise pollution, disruption of urban life, and sheer physical space devoted to vehicles in cities—would remain unaccounted for. Since those costs are largely local in nature, it would make sense to adopt local policies to manage them.

If state and local governments should choose to complement a gas tax increase with measures to encourage efficient use of urban space or to offset localized social costs, they have a number of policy options. To encourage drivers to shift to transit, local transit agencies could institute flexible forms of transit and pricing systems that reflect time-of-day costs. When the technology becomes available, they could implement congestion charges in tandem with higher parking fees. States could institute "pay-at-the-pump" auto insurance, so that those who drive more would pay more. Finally, if increasing the density of cities is seen as a method of reducing total driving, measures such as location-efficient mortgages, incentives for brownfield development, and new methods of financing transit development could be of use. These policy options for state and local officials are discussed in more detail in Section VI.

II. ESTIMATING THE SUBSIDIES TO DRIVING

Subsidies Defined

A subsidy exists whenever one person or group is burdened with a cost while another person or group receives a corresponding benefit.[5] Subsidies can take the form of a private cost that is paid in cash by someone else or a social cost that is suffered by someone else without any exchange of money. In either case, there is a net transfer of something of value from one category of people to another. We are accustomed to thinking of subsidies to the poor in the form of food and housing, subsidies to farmers in the form of cheap water and crop price supports, and a multiplicity of subsidies to other businesses. In those cases, the bank accounts of taxpayers go down and the accounts of the recipients go up.

But subsidies also occur when no money changes hands and when transfer from payer to recipient does not involve the government. If I dump waste in a river and the people downstream become ill, they are subsidizing my behavior. In this case, the health account of those downstream declines, and my convenience account rises by being able to dump the waste untreated. If I am required to pay a fee per marginal unit of damage I cause, I will start treating the water I dump, and the health of the people downstream will improve. The payment closes the loop and ends the subsidy, even if the people downstream never receive any direct compensation.

Part of the calculation to determine the total subsidy received by drivers involves making a plausible estimate of the value of the damage that members of a society incur as a result of driving. Any uncompensated damage amounts to a subsidy because drivers benefit from mobility and others suffer undesirable side effects.

Driving as a Subsidized Activity

The premise of this study is that driving is a heavily subsidized activity. Although many experts concur with this view, it is not universally shared. For example, several analysts have argued that driving is not subsidized (Pozdena 1995, Green 1995, and Dougher 1995); they have even claimed that drivers subsidize mass transit, or that driving generates positive side effects that outweigh any undesirable ones.[6]

The claim that drivers subsidize other taxpayers is based on an accounting procedure that purports to show that drivers pay more in fees than is spent by government on streets and highways. In order to make that case, the libertarian critics treat taxes and fees as equivalent.[7] Specifically, they treat all registration, sales, and personal property taxes paid for vehicles as equivalent to road-use fees and tolls. This approach involves a fundamental conceptual mistake: It fails to differentiate ownership of vehicles from the use of them. The fact that government unwisely levies various taxes on vehicle owners does not transform those taxes into user fees. Tolls and fuel excises are the only fees that can legitimately be called user fees because they are levied in some reasonable relationship to road use.

Classification of Subsidies

Subsidies to driving can take at least two general forms: (1) a private cost paid by someone else or (2) a social cost that does not involve an exchange of money.

In the case of unpaid private costs, the subsidy is generally explicit because other taxpayers pick up the tab. Someone drives down the road, and someone else pays part of the cost of building and maintaining that road. Some private costs are implicitly subsidized (implicit subsidies cannot be easily measured), but these costs do not show up as a line item in any budget. A good example of this is when depreciation of highways exceeds the money spent to maintain them. That is a real cost to future drivers, and an implicit subsidy to those using up the roadways today.

The subsidy represented by unpaid social costs is mostly implicit. For example, the costs of damage caused by air, water, and noise pollution and climate-forcing emissions cannot be directly measured, so they must be inferred. The same is true of the costs of congestion and the social disruption of neighborhoods intersected by high-speed traffic. To some extent, the social costs of accidents can be estimated from direct evidence (public spending on medical expenses of injuries not covered by insurance). However, the costs of mortality and morbidity associated with accidents can only be inferred.

Determining the amount of subsidy received by motorists in the United States involves estimating the residual cost imposed by driving after accounting for expenses that motorists already pay. Rather than distinguish between explicit and implicit subsidies, this paper instead categorizes subsidies as either direct or indirect. Direct subsidies involve a cash outlay by some level of government—that is, one group makes tax payments that directly benefit another group. Indirect subsidies generally involve no cash transfers. Both types of subsidies are explained in more detail below.

Direct Subsidies

If those who do not benefit from highways and protection of petroleum supplies are paying part of those costs, then drivers are receiving a direct or explicit subsidy. This section estimates the amount that drivers would have to pay to eliminate that subsidy.[8]

1. Street and Highway Expenditures Minus Fees

Drivers of private vehicles pay a user fee, in the form of fuel taxes, that covers part of the cost of streets and highways. Some states also impose tolls on certain highways. According to the Federal Highway Administration (FHWA), highway user fees, including tolls, raised $59.6 billion in 1995 (U.S. FHWA 1995, table HF-10, errata sheet). Of that amount, light-duty passenger vehicles (cars and light trucks) pay about $42 billion.[9]

The cost of providing state and federal roads and highway services for those light vehicles is approximately $84 billion. That total represents 60 percent of the $60 billion in annual replacement costs for existing highway infrastructure plus 90 percent of the $41 billion in costs for maintenance and traffic services, administration, research, and law enforcement and safety.[10] The net effect is that drivers of light vehicles receive an annual direct subsidy of about $31 billion ($73 billion minus $42 billion) for the use of the federal and state highway system.[11]

The costs of driving are also subsidized locally from property taxes and other revenue sources, which pay for paramedic assistance to accident victims and various public works expenses at the local level. This subsidy can be conservatively estimated at $9 billion per year.[12]

Thus, the combined subsidy to passenger vehicles that results from underpayment of highway and street costs is about $40 billion. Around $31 billion is a federal and state subsidy, and $9 billion is a local subsidy.

2. Federal Guarantee of Petroleum Supplies

Americans have become very dependent on foreign petroleum. In 1996, about 46 percent of the petroleum consumed in the United States was imported, compared to just 35 percent in 1973 (U.S. EIA 1997b). The U.S. government spends large sums to ensure the continued availability of petroleum to American consumers. This amounts to a subsidy to drivers from other taxpayers.

One aspect of this direct subsidy is providing for the Strategic Petroleum Reserve at home. The reserve's cost is relatively small—about $1 billion per year.[13]

Another aspect of this direct subsidy is the money spent protecting oil supplies overseas. Estimating this cost involves some arbitrary assumptions regarding what should and should not be included. For example, MacKenzie, Dower, and Chen (1992, 17) estimate that motor vehicles use about one-half of the oil consumed in the United States; they therefore assign half of annual U.S. expenditures for protection of Middle East petroleum to the cost of driving—about $25 billion in 1991 dollars. Delucchi and Murphy (1997) whittle that figure down considerably. They conclude that only $0.6 to $7.0 billion of the cost of protecting Persian Gulf oil should be assigned to highway transportation (and only $0.4 to $5.2 billion to cars and light trucks).

Using Delucchi and Murphy's data, but applying some differing assumptions, the cost of protecting the Persian Gulf petroleum used by U.S. passenger vehicles is estimated here as between $8 and $10 billion per year.[14] The cost of providing a military presence in the Persian Gulf is only a fraction of the total cost of protecting petroleum supplies overseas. A more comprehensive analysis would consider the money the U.S. spends "stabilizing" other regions. I have estimated the total cost of U.S. military protection of oil supplies as $18 billion, double the Persian Gulf estimate derived from Delucchi and Murphy.

In total, then, the cost of guaranteeing oil supplies to the users of passenger vehicles in the United States is $1 billion for the Strategic Petroleum Reserve and $18 billion for military services, or $19 billion in total.

3. Total Direct Subsidies

The direct subsidy to drivers from general tax revenues thus amounts to $70 billion: $51 billion for highway costs plus $19 billion for oil security costs, each paid by third parties.

Indirect Subsidies

Most subsidies of driving fall into the indirect category. These include accident costs not covered by drivers' insurance, air pollution, water pollution, noise pollution, climate change, and underpriced parking.

1. Accident Costs Not Covered by Drivers

Accidents impose a cost on outsiders if the resulting death or injury is suffered by a pedestrian or cyclist, or if the public pays part of the medical costs of the victims. This is only true of those costs not covered by private insurance.

The most common approach to analyzing the external costs of accidents is to sum the value of medical expenses, loss of productivity, and other opportunity costs associated with accidents. This "human capital" approach to loss of productivity involves the morally dubious task of valuing the loss of particular lives, which tends to assign a higher weight to high-income individuals. Historically, this has led to valuing lives in terms of a few hundred thousand dollars of forgone wages, discounted to the current year.[15]

A second approach estimates the statistical value of life according to the premiums required to induce people to accept greater risks. This avoids the problem of saying that the life of a particular person has a specific monetary value, but instead describes the relationship between risk and value. Thus, roughly speaking, if people in high-risk occupations require an extra $1,000 in discounted lifetime earnings to compensate for an increase in the likelihood of death to one in 5,000, that would signify a statistical value of life of $5 million. Several recent studies have estimated the value of a statistical life in this way. Based on these studies, the value of a statistical life is here conservatively estimated at $3 million.[16]

Since there were about 7,000 third-party fatalities in 1995, their total cost was approximately $21 billion.[17] If the cost of a statistical injury is $50,000 (about one percent of the value of a statistical life), the cost of the more than 100,000 third-party injuries is about $5 billion.[18] In addition, the public and hospitals bear an estimated $10 billion in uninsured medical expenses associated with accidents (Lee 1995, 12).[19] Thus, the sum of the costs of fatalities, injuries, and public medical costs is about $36 billion per year.

2. Air Pollution

Heavy reliance on cars and trucks has increased urban air pollution problems, a condition that has only been partially mitigated by emissions controls. The damage imposed by air pollution from motor vehicles comes mostly from emissions of four primary pollutants and their by-products. In the United States, transportation is responsible for 66 percent of carbon monoxide emissions, 43 percent of nitrogen oxides, and 48 percent of volatile organic compounds (Small and Kazimi 1995, 9, citing Ball, Hamilton, and Harrison 1991).[20] Cars and trucks also generate large volumes of coarse and fine particulates.

According to the exhaustive work of McCubbin and Delucchi (1996, tables 11-A-1 and 11-A-2), the annual cost of emissions from gasoline-powered vehicles are as follows (in 1995 dollars, with geometric means in parentheses):[21]

Pollutant	Estimate ($billions)
Carbon dioxide	1.1 - 9.3 (3.2)
Nitrogen oxides	1.0 - 5.3 (2.3)
Ozone	0.2 - 1.9 (0.6)
PM10	17 - 314 (best estimate: 50)

Because the estimated range for the health effects of particulates is so large, data from McCubbin and Delucchi (240-41) have been used to construct a "best estimate" of $50 billion.[22] Adding the other damage estimates yields a total of $56 billion in damage from air pollution.

In addition to damage to health, air pollution also causes about $3 billion in damage to crops and $3 billion in loss of visibility.[23]

Combining health damage, crop damage, and visibility loss results in a comprehensive estimate of $62 billion for the damage caused by air pollution from light passenger vehicles.

For purposes of comparison, other estimates of air pollution damage (in 1995 dollars) from cars and light trucks include:

Estimate ($billions)	Source
12	MacKenzie, Dower, and Chen (1992, 13)
28 - 32	California Energy Commission (1994, 29)
139 - 255	Miller and Moffett (1993, 48)
15 - 68	Hall et al. (1992, 816)
80	Small and Kazimi (1995, 25)

(Note: In the case of the last two studies, I have extrapolated estimates for the Los Angeles region, as reported in McCubbin and Delucchi (p. 243), to the nation as a whole. This presumably biases their numbers upward, since health effects in Los Angeles are worse than average.)

3. Water Pollution

Water pollution results from acid rain, runoff of deposited chemicals from pavement, herbicide spraying along rights-of-way, and road salt—all of which damage vegetation and aquatic wildlife. Far less attention has been paid to quantifying the cost of these forms of damage than to the costs of air pollution. The cost of water pollution is here estimated as about $6 billion per year; this is an average of the following three estimates, all of which have been transformed into 1995 dollars:

Estimate ($billions)	Source
2.3	U.S. OTA 1994, table 4-6, 108, midpoint of range
4.4	Miller and Moffett 1993, 50
11.1	Lee 1995, 12, based on 1/2¢ per vehicle mile traveled

4. Noise Pollution

Building freeways and high-speed arteries to accommodate automobiles has disrupted cities with noise that causes health problems and makes neighborhood life less enjoyable. The value of traffic noise reduction has been estimated in several studies by examining the changes in residential property values that occur after noise levels change.[24]

Estimate (in 1995 $billions)	**Source**
2.4 - 14.4	Litman 1995, 3.11-2 to 3.11-525
7.6 (urban interstates)	Hokanson, Minkoff, and Cowart, 1981, 21
6.4	Lee 1995, 12
11.0	MacKenzie, Dower, and Chen 1992, 21
0.1 - 15.0	Delucchi 1996, table 1-9a

Litman (1995, 3.11-5) argues that hedonic methods of valuation underestimate the true cost of traffic noise by a factor of two to eight since they ignore the damage and discomfort outside homes (i.e., on the street or at work). He cites Verhoef (1994, 286) who says that hedonic estimates count only one-eighth of the total cost. On the other hand, trucks account for a disproportionate amount of traffic noise. Thus, total noise damage is probably far greater than the figures cited above, but only a portion of those costs are caused by cars and light trucks. The existing figures are therefore reasonably good estimates of the damage caused by passenger vehicles. Based on these, the cost of traffic noise from light vehicles is estimated here as approximately $8 billion, the mean and median of the five estimates shown above (using the midpoints of the two ranges listed).

5. Climate Change

Gasoline consumption by private vehicles is a major reason the United States is the largest source of greenhouse-gas (GHG) emissions in the world. Because carbon dioxide and other GHGs will remain in the atmosphere for a century or more, the effects of these emissions on the world's climate is cumulative and irreversible during the average life span.

The total annual cost of climate change to the world economy is projected by the Intergovernmental Panel on Climate Change (Bruce, Lee, and Haites 1996, 203 and 205) to be $270 to $316 billion. The midpoint of that range is $293 billion. U.S. emissions account for about 22 percent of human-generated emissions; consequently, worldwide damage from U.S. emissions would be around $66 billion per year. Since about 20 percent of U.S. GHG emissions come from the combustion of gasoline (U.S. EPA 1996, A-8), the cost assigned to U.S. motor vehicles would be about $13 billion per year.

6. Underpriced Parking

Underpriced parking imposes an important hidden cost on society and lowers the perceived cost of driving. The cost of providing parking spaces amounts to an estimated $59 billion per year.[26] Since 99 percent of all parking for work and shopping trips is not paid for by drivers (Shoup 1997, 22), the cost of parking is almost entirely subsidized. However, this subsidy is unrelated to the use of gasoline or the distance traveled on highways. It is therefore not included here in the overall estimate of the subsidy that could reasonably be offset with additional gasoline taxes. However, the parking subsidy may be the single largest subsidy to drivers.[27]

In addition to the direct subsidy to drivers involved in providing free parking, there is an indirect subsidy of perhaps equal magnitude. Shoup (1997, 9-11) argues that the parking requirements imposed by cities on new development decrease residential and commercial densities by around 30 percent. Thus, the density of cities that have imposed minimum parking requirements on developers is perhaps 10 to 15 percent below the density that would have occurred in an unregulated market. The costs associated with below-market levels of density are difficult to calculate, but they are real. They include higher costs for all publicly provided infrastructure to accommodate a given number of people in a larger area. They also include the added travel time and other transaction costs required to move people and products greater distances within cities. No estimates are offered here of these costs, but they probably total tens of billions of dollars.

Summary of Costs or Subsidies

Table 1 summarizes the costs of driving that are not currently paid for by the beneficiaries; these are conservatively estimated as $59 billion in direct subsidies and $125 billion in indirect, for a total of $184 billion per year.

There are a number of additional costs imposed by driving that cannot easily be monetized; these are therefore excluded from the present analysis. One such invisible cost of driving is lost sociability: the tendency of the less mobile parts of the population to stay inside and not make contact with other people because motor vehicles dominate public space. Major arterial roads divide neighborhoods from each other, acting as barriers to pedestrians—especially to children, the elderly, and the carless (Litman 1995, 3.13-1). The cost of the barrier effect is the trips that pedestrians or bicyclists forgo because they are afraid of harm on increasingly busy streets.[28] In addition, to the extent that neighborhoods are intersected by streets bearing heavy traffic, the amount of casual conversation and play among children is reduced (Appleyard 1981, Chapter 2). Although these sorts of costs are difficult to quantify, they are real. Moreover, the existence of these added social costs reinforces the likelihood that the true cost of driving, as presented here, is understated, rather than overstated.

Setting a Tax Rate to Recoup Costs

Now that the cost of driving has been estimated, the tax that drivers would need to pay to offset the damage they cause can be determined.

Table 1

ANNUAL SUBSIDIES TO THE DRIVING OF PASSENGER VEHICLES ($BILLIONS)

I. DIRECT SUBSIDIES			
A.		**Net costs of highways attributable to light-duty passenger vehicles**	
	1.	Annualized replacement cost of highways (60% of $60 billion)	36
	2.	Maintenance and traffic services, administration and research, and law enforcement and safety (90% of $41 billion)	37
	3.	Total highway cost of passenger vehicles (1+2)	73
	4.	User fees and tolls paid by passenger vehicles	(42)
	5.	Net cost (unpaid by users) (3+4)	31
	6.	Cost of local streets and services (net of local tolls and fees)	9
	7.	Total subsidy to light-duty passenger vehicles from underpaid costs of streets and highways (5+6)	40
B.		**Costs of defending oil supplies**	
	8.	Strategic Petroleum Reserve	1
	9.	Military protection of oil supply lines	18
	10.	Total cost of guaranteeing oil supply (8+9)	19
C.		**Total direct subsidies** (7+10)	59
II. INDIRECT OR IMPLICIT SUBSIDIES TO PASSENGER CARS AND TRUCKS			
A.		**Accidents** (uncompensated damages)	
	11.	Value of third-party lives lost (pedestrians and bicyclists)	21
	12.	Value of third party injuries sustained	5
	13.	Uninsured medical expenses paid from public funds	10
	14.	Total cost of accidents not paid by drivers (11+12+13)	36
B.		**Air pollution**	
	15.	Damage to health	56
	16.	Crop damage	3
	17.	Visibility loss	3
	18.	Total air pollution costs particulates (15+16+17)	62
C.		**Water pollution**	6
D.		**Noise pollution**	8
E.		**Global warming**	13
F.		**Subtotal of indirect or implict subsidies** (14+18+C+D+E)	125
III. TOTAL SUBSIDY—DIRECT AND INDIRECT (C+F)			184
IV. SUBSIDY PER GALLON ($184 billion divided by 115 billion gallons)			1.6

1. The Ideal Set of Fees or Taxes

In the best case, every form of damage would be offset by a fee that would create a direct link between the amount of damage caused and the amount of fee paid. Not only would there be a specific fee for air pollution, that fee would distinguish among the amount of carbon monoxide, volatile organic compounds, nitrogen oxides, and particulates emitted by each vehicle. Fees to cover the cost of highway deterioration would vary according to the vehicle's weight and distance traveled.

Those are the kinds of fees we could expect if information were free and transaction costs had been eliminated. In reality, however, we are bound by administrative feasibility, which precludes most ideal fees. The various factors that combine in each vehicle to cause damage cannot be monitored easily. Although there is substantial evidence of a large variance in the emissions of different vehicles—which makes an average fee per mile or per gallon of gasoline unfair—there is no adequate means of monitoring and tracking the emissions of millions of individual vehicles under various operating conditions. (This is true despite the existence of remote sensing technology. Even if that technology were in place and the computer software existed to assign fees to owners on the basis of those on-road readings, there is not yet a good method of measuring the emission of particulates, which is the largest component of health costs.)

Consequently, for now we must rely on either a per mile charge or a gasoline tax to capture the costs of driving. This report considers only a gasoline tax, for two reasons. First, a per mile charge would require government inspection of odometers, which would undoubtedly lead to tampering with those devices and to complaints of government intrusion into the private affairs of citizens. Since some damage occurs on a per mile basis, attempting to overcome resistance to a per mile charge will be necessary in the long run. For the time being, the less intrusive gasoline tax is easier to administer. Second, many studies have examined the effects of changes in gasoline prices on behavior; few (if any) have examined the effects of per mile fees. Thus, examination of the effects of per mile fees would of necessity rely on studies of gasoline prices as a proxy.

2. Average versus Marginal Costs

In estimating the appropriate level of a tax used to internalize costs, a distinction should be made between average and marginal costs. The average cost imposed on society by driving is the sum of all external costs divided by miles driven. The marginal cost, which is much harder to estimate, is equal to the value society loses with an additional unit of driving.[29] If the last unit of travel imposes greater or lower costs per mile than earlier travel, the marginal cost gives a more accurate estimate of the social gains from reduced driving. If there were threshold levels of highway deterioration, accidents, or pollution above which damage increased more rapidly than before, marginal costs would be higher than average costs. It appears, however, that damage is closely proportional to road use and the amount of driving that occurs. (For a discussion of the close approximation to linearity of air pollution damage, see Delucchi 1996, Section 1.2.1 and Section 1.3.3.)

Although there appears to be no significant difference between marginal and average costs, there is almost certainly variance in costs among different cities or regions. For example, the cost per unit of air pollution is presumably greater in Los Angeles than Seattle. Thus, an ideal tax policy might be to set a federal tax at the base level of damage for all regions, leaving state and local governments to set additional taxes to capture local differences in damage levels. That level of refinement in policymaking is beyond the scope of this report, which examines only national averages.

3. The Estimated Tax Rate

The tax rate is calculated on the basis of average cost (amount of damage) per gallon of gasoline consumed. Since 115 billion gallons of gasoline were consumed in passenger vehicles (cars and light trucks) in 1995 (U.S. FHWA 1997, I-3,table

MF-21) and the estimated cost was $184 billion, the tax rate would be $1.60 per gallon.[30] This charge would be phased in over a period of ten years to ease transition costs.

Since the price of gasoline (including state and federal taxes) in the mid-1990s has averaged about $1.25 per gallon, a $1.60 per gallon added charge on gasoline would thus amount to a 127 percent increase in the price facing consumers after ten years, assuming the base price remained constant. The estimates here and in the following sections assume that all future prices have been adjusted for inflation.

III. THE DIRECT EFFECT OF AN ENVIRONMENTAL TAX SHIFT

How a Tax Shift Would Work

One aspect of a tax shift could involve an increase in the tax on gasoline, offset by a cut in taxes on wages and investment in order to strengthen the economy's productive capacity. Since the net effect would be revenue neutral, households would, on average, experience no overall increase or decrease in disposable income; the impact on individual households, however, would vary depending on behavioral responses due to the price change.

Effects of a Tax Shift on Driving

Raising the price of gasoline leads to several direct outcomes. One involves a reduction in miles driven. The second involves an improvement in the fuel efficiency of new cars, so that cars will use less fuel per mile driven. The combined effect of these two changes is a third outcome: a reduction in gasoline consumption. Of these outcomes, the easiest to measure is fuel consumption.

The following discussion considers the responsiveness of various factors to the price of gasoline and to income. Economists refer to this relationship as "elasticity." Price elasticity of demand simply means the change in amount of purchases of some product or service as price goes up or down. Price elasticity of demand is calculated as the percentage change in sales divided by the percentage change in price. Income elasticity of demand means the percentage change of sales divided by the percentage change in income. Thus, if people drive 3 percent fewer miles when the price of gasoline rises by 10 percent, the price elasticity is -0.3.

This report focuses entirely on the long-run elasticity of gasoline sales. This permits examination of the behavior of motorists after they have had a number of years to adjust to higher gasoline prices by buying a more fuel-efficient vehicle, increasing the use of carpools or transit, and possibly even moving to a new location that will permit a shorter commute.

1. General Modeling Issues

When the price of gasoline rises, less of it is purchased. When households have more income, they spend more on gasoline. That much is common sense. But determining the exact price and income elasticities of gasoline demand requires more than common sense. With several factors determining consumer behavior, elasticities cannot be observed directly from consumer behavior.

Modeling with regression analysis can be used to estimate elasticities. In the models, demand for gasoline is a function of current price, current income, and other relevant factors including stock and characteristics of vehicles and anticipated future price changes (which can be roughly modeled as earlier changes in price). Errors inevitably crop up in regression models that distort or bias the answer; these can be controlled for, but never entirely eliminated. It is thus not possible to know whether a given answer is the "right" one. (In addition, if two models treat the same factors in slightly different ways, or if they include somewhat different factors, the results can be quite different.)

The purpose of a model is to determine how factors vary with each other. The results of a model are most reliable if variables' amplitude of change is large. In the case of gasoline, the large changes in price in the 1970s (upward) and 1980s (downward) more clearly show the effects of price changes on demand than do data from the 1950s and 1960s, when price changes were small. Studies using more recent data are thus likely to be more reliable than earlier studies.

For the same reason, since incomes and gasoline prices vary widely across countries, cross-sectional analysis provides a clearer signal of price and income effects than data from any individual country. On the other hand, comparisons across countries may ignore other factors (such as population density or regulatory controls) that affect travel behavior.

Since households do not instantly change their cars and trucks when a price change occurs or when their incomes rise, a model that seeks to measure long-run elasticities must also take into account the delay in responding to changes.[31] An important feature of recent studies involving only the United States has been the inclusion of federal corporate average fuel efficiency (CAFE) standards in models. CAFE standards have required automakers to design cars and light trucks that theoretically achieve a specified level of fuel efficiency. If a model does not take this into account, some of the efficiency gains resulting from CAFE might be ascribed erroneously to the incentive effect of fuel prices.

2. Statistical Results

Table 2 shows the results of a number of models developed in the 1990s. The demand for gasoline is mediated through three effects: fuel efficiency, distance traveled per vehicle, and the number of vehicles on the road. When the price of gasoline goes up, people shift to more fuel-efficient cars and trucks,[32] travel less, and buy fewer vehicles. When incomes go up, however, people shift to less fuel-efficient vehicles, travel more, and buy more vehicles. The net result is based on the combination of opposing forces.

The median estimates from recent studies are repeated in Table 2A. For convenience and consistency, "fuel efficiency" (miles per gallon) has been changed to "fuel use per mile" (or gallons per mile); this changes the number from a positive to a negative, as in the other categories. (This change can be made because, when the price of gasoline rises, fuel efficiency also rises but the reciprocal, fuel use per mile, declines.)

To check these results, the sum of lines two, three, and four can be compared to line one. The fact that the numbers in line five are greater (in absolute terms) than those in line one suggests that these estimates for gasoline demand may be somewhat conservative. On the other hand, it might also suggest that statistical techniques are better at estimating aggregate effects (amount of gasoline consumed) than all of the components that affect consumption.

Table 2

LONG-RUN REGRESSION ESTIMATES—PRICE AND INCOME ELASTICITY

AUTHOR OF STUDY	PRICE	INCOME	YEAR OF STUDY
1. Gasoline consumption			
This study	-0.77	1.20	1998
Dahl	-1.02	1.38	1986, p. 73
Espey	-0.53	0.64	1996, p. 54
Goodwin	-0.77	NA	1992, p. 157
Schimek	-0.73	1.43	1996, p. 85
Schipper/Johannson	-0.85	1.20	1994, p. 18
Sterner/Dahl	-0.86	1.21	1991, p. 210
Sterner/Dahl/Franzen (a)	-1.00	1.00	1992, p. 113
Sterner/Dahl/Franzen (b)	-0.79	1.17	1992, p. 113
Wooster/Pickrell	-0.73	1.43	1990s (n.d.)
(a) = U.S. (b) = 21 countries			
2. Fuel efficiency			
This study	0.53	-0.06	1998
Dahl	0.57	-0.21	1986, p. 69
Haughton/Sarkar	0.58	-0.06	1996, p. 118
Nivola/Crandall	0.39	NA	1995, p. 47
Schimek	0.23	-0.06	1996, p. 85
Schipper/Johannson	0.55	0.00	1994, p. 18
Wheaton	0.32	-0.21	1982
Wooster/Pickrell	0.53	-0.13	1990s (n.d.)
3. Miles driven per vehicle (VMT)			
This study	-0.23	0.28	1998
Dahl	-0.55	0.60	1986, p. 69
Goodwin	-0.31	NA	1992, p. 157
Haughton/Sarkar	-0.22	0.28	1996, p. 118
Nivola/Crandall	-0.23	0.55	1995, P. 135
Schimek	-0.30	0.31	1996, p. 85
Schipper/Johannson	-0.20	0.20	1994, p. 18
Wooster/Pickrell	-0.23	0.23	1990s (n.d.)
4. Vehicle stock (number of vehicles being driven)			
This study	-0.13	1.14	1998
Schimek	-0.14	1.14	1996
Schipper/Johannson	-0.10	1.00	1994, p.18
Wooster/Pickrell	-0.13	1.55	1990s (n.d.)

Table 2A

SUMMARY OF ELASTICITIES: GASOLINE AND VEHICLE USE

	Price	Income
1. Gasoline demand	-0.77	1.20
2. Fuel use per mile	-0.53	0.06
3. VMT per vehicle	-0.23	0.28
4. Number of vehicles	-0.13	1.14
Total of lines 2, 3, 4	**-0.89**	**1.48**

Table 3

EFFECTS ON DRIVING OF A $1.60 GASOLINE TAX INCREASE PHASED IN OVER 10 YEARS

Gasoline use	71% less
Fuel use per mile	66% less
Miles traveled per vehicle	23% less
Vehicles in operation	9% more
Total vehicle miles	14% less

3. Net Effects

Table 3 summarizes the effects of a gasoline tax of $1.60 per gallon based on the estimated price and income elasticity measures and an assumed growth of per capita income of 2 percent per year.[44] By phasing the tax in over a ten-year period, the effects on gasoline use and miles traveled are attenuated because the income effect offsets the price effect.

All of these estimates are based on future projections of past trends. There are several reasons to be cautious about accepting them.

First, elasticity estimates are often valid over only a small range of prices and incomes. If the price of gasoline rose and consumers cut back on discretionary trips, price sensitivity on the remaining trips would be lower than today. Sterner, Dahl, and Franzen (1992, 113) found evidence that the price elasticity of gasoline in high-price countries is generally lower than in the United States, although there is not a consistent pattern. It is likely that the price elasticity of gasoline consumption would decline as the price rose, but by how much and starting at what price is not clear. If that is the case, the estimates of reduction in fuel use, fuel use per mile, and miles traveled are too extreme (that is, too large in absolute value).

Second, methodological controversy continues to surround the estimation of these elasticities. If fuel use per mile is less sensitive to the price of gasoline than the estimated price elasticity used here (-0.53) would suggest, the effect on fuel use would be substantial. If the price elasticity is -0.3, the reduction in fuel use per mile in ten years would be only 37 percent instead of 66 percent. The reduction in fuel use would then be around 50 percent.

On the other hand, there are two reasons for believing that these calculations underestimate the changes that would occur if a large gasoline tax were imposed. First, some improvements in fuel efficiency are likely to occur even without an increase in the gasoline tax to spur them. According to Nivolla and Crandall (1995, 136), technological progress in engineering has caused the fuel efficiency of new passenger cars to increase by 2.4 to 3.2 percent per year (from 1968 to 1992) and the average efficiency of all cars on the road to increase by 1.2 to 1.7 percent. (This is separate from the effect of CAFE standards, for which they also account in their model.) If this trend is "real" and not a statistical artifact, then fuel efficiency will improve by 30 percent per decade—even without a gasoline tax.

Second, the change that will occur with higher gasoline prices may be understated if past trends overstate the future income elasticity of the vehicle stock. Transportation analyst Charles Lave (1990, 3) argues that in the United States, "vehicle ownership is essentially saturated."[45] The baby boom has passed, as has the disproportionate growth of female workforce participation. The number of vehicles per person of driving age is now growing very slowly. If rising income causes only half as large an increase in vehicles per person as anticipated (i.e., if the income elasticity is 0.57 instead of 1.14), the vehicle stock would decline by 4 percent, and the decline in gasoline consumption would be correspondingly greater as well.

4. A Rough Comparison with the European Experience

Could fuel use in the United States actually be cut by 50 to 70 percent by raising the gasoline tax? We will not know with certainty until such a tax is imposed. It is possible, however, to get a sense of the effect of such an increase in the gasoline tax by observing the experience of other industrialized countries.

In Western Europe, where the price of gasoline averaged only about 100 percent higher during the mid-1980s than in the United States, per capita fuel consumption in 1993 was about 64 percent lower than in the United States. In other words, a price difference less than the tax increase considered in this report made a big difference. Part of the reason is that per capita incomes are about 20 percent lower in Europe than in the U.S. (U.S. Department of Commerce 1993, 854). But the main factor is that Europeans chose to drive more efficient vehicles, not fewer miles.[46]

IV. EFFECTS OF A GAS TAX ON CARPOOLS, VANPOOLS, AND TRANSIT

The three first-order effects of a rising tax on gasoline discussed above were a shift to more fuel-efficient vehicles, a reduction in the use of each vehicle, and a slower rate of growth of the number of vehicles in operation. The second of these effects, a reduction in VMT per vehicle, does not necessarily mean that people would travel less. It may simply mean that people travel together. In order for that to occur, alternatives must be available to traveling in single-occupancy vehicles.

In the past, people have reduced driving by opting for one of two forms of collective transportation: ridesharing or public transit. In the future, this mode shift could include carpools and vanpools as methods of ridesharing, and various forms of public transit, including some (such as jitneys) that are not common today.

Ridesharing: Carpools and Vanpools

The simplest mode shift involves the formation of carpools for commuting. Drivers and riders may receive help in making a connection with each other from employers or from local government. A carpool retains many of the advantages of driving alone: speed, flexibility, and minimum waiting time. Nevertheless, because there is some loss of convenience and privacy, some incentive is required to promote carpool arrangements.

Vanpools are more formal than carpools. They are generally organized by institutions (especially employers) rather than by individuals. Commuting in a vanpool does not require as great a sacrifice in terms of time and trouble as reliance on a local bus or light-rail system. In this regard, it is like carpooling, thus permitting joint discussion of these two commuting options.

Based on recent experience, ridesharing is sensitive to the price of gasoline and to incomes. As gasoline prices fell in real terms and incomes rose during the 1980s, ridesharing declined by almost one-third: from 13.8 percent of commute trips in 1985 to 10.8 percent in 1989, according to the American Housing Survey (Ferguson 1994, 2-6, 2-7, 2-9). The Nationwide Personal Transportation Survey (NPTS) records a drop in the average vehicle occupancy of work trips from 1.32 persons per vehicle in 1977 and 1983 to 1.16 in 1990 (U.S. FHWA 1993, table 7-16).

Ferguson (1994, 2-10) has estimated that the elasticity of demand for carpooling with respect to gasoline prices is about 0.25 to 0.35. That is approximately the same as the price elasticity ofVMT per vehicle. When gasoline prices rise (or fall), vehicles are driven less (or more), but people do not decrease (or increase) their travel. This finding suggests that people respond to a rise in price by carpooling and to a decline in price by shifting back to driving alone.

The effect of rising incomes on carpooling appears to be even more pronounced than gasoline prices, although no income elasticity measures are available. Increases in household income have caused a long-term downward trend in carpooling, which was temporarily offset in the years 1974-75 and 1979-80 by price spikes and gas rationing.

Several studies confirm the direct influence of income on carpooling decisions. The 1990 NPTS shows that carpooling declines from about 28 percent in families with incomes below $10,000 to about 15 percent as family income rises to $30,000, then levels off (Ferguson 1994, 2-24). Teal (1987, table 3, 207) showed that when the cost of driving alone exceeds 5 percent of a worker's family income, he or she is two to three times more likely to carpool than wealthier workers. Hartgen and Bullard (1993, 57) found a negative correlation between per capita income and propensity to carpool in North Carolina; Matthews (1993) found a similar association in Georgia.

The effect of income derives primarily from two factors: decreasing household size and increasing vehicles per household. As the country has grown richer and more individuals have access to their own cars, there is less incentive to carpool, even with other family members. Since these income effects will remain and grow, even large increases in the price of gasoline are unlikely to raise carpool rates much above the 20 percent level of 1970 to 1980.

Declining population density (i.e., increasing suburbanization) appears to have had little effect on the decline of carpooling. Although a density greater than ten people per square mile has a significant effect on transit use, it has little effect on carpooling (Ferguson 1994, 2-20). Transit comprises about 9 percent of mode share at ten people per square mile and about 54 percent at seventy people per square mile, while the share for carpooling remains between 10 and 20 percent at all densities.

Since carpool rates appear to be the inverse of VMT per vehicle, it is plausible to expect that carpooling would increase by around 20 percent over a decade as the tax on gasoline rose. The carpool rate would thus rise from around 11 percent of commute trips to between 13 and 14 percent—or approximately the same level as in the early 1980s. Unless the number of vehicles grows much more slowly than in the past, an increase in carpooling of this magnitude would have little effect on congestion.

Fixed-Route Transit

Another mode shift that would occur as a result of a rise in the cost of driving would be increased transit ridership. This is true, of course, only for urban and suburban drivers who live in areas served by transit. Rural driving would not be much affected by this option.

In fact, though, the shift to transit in cities would also be rather small. Higher incomes and more dispersed cities caused per capita transit ridership to fall by 76 percent in the past few decades: from 116 transit trips per person per year in 1950 to only 28 per year in 1995.[47] Many transit enthusiasts seem to imagine that requiring drivers to pay the full cost of operating a vehicle would dramatically reverse the long downward trend in transit use. Based on the experience in many cities during the oil crises of the 1970s, that might seem plausible. But it is incorrect. The shift to transit from even a large gasoline tax is likely to be small.

Only a few studies on the cross-elasticity of transit ridership with respect to the price of gasoline have been conducted. Wang and Skinner (1984, 38) estimated elasticities for seven cities of varying sizes. With one exception, all of the statistically significant estimates fell close to 0.2, indicating a relatively small effect. Wang and Skinner also refer to studies of Tucson, Atlanta, and San Diego (one of which was in their sample) and a national sample. The average elasticity in those other studies was 0.3. Thus, it seems plausible that the elasticity of transit demand relative to the price of gasoline is about 0.25.

Estimates of income elasticities of transit ridership are even more elusive. Nevertheless, it seems fairly clear that the reason for the long-term downward trend in transit ridership in the United States (and, to some extent, in other countries) is a function of rising incomes. In 1977, those earning less than 40 percent of the median income made 6.9 percent of their total trips by transit, while those with incomes above the median made only 2.5 percent (Pucher, Hendricksen, and McNeil 1981, 466). In 1990, those with incomes below $10,000 made 3.7 percent of their trips by transit, compared to 1.3 percent by those with incomes of $30,000 to $40,000 (U.S. DOT 1993, table 4.34). It is not possible to estimate an income elasticity of transit ridership from these data, but it appears that transit use has decreased at all income levels over time as incomes have increased. In effect, people "buy their way" out of dependence on transit as incomes rise and more members of each household have access to a car.

Most of the effect of a gasoline tax on transit use will therefore be outweighed by a general rise in incomes, even if the tax is quite large. A 127 percent increase in the real price of gasoline over a period of a decade when incomes rise by 20 percent might therefore translate into only a 12 percent increase in transit trips.[48]

Since the U.S. population is likely to grow by nearly that much in a decade, transit trips per capita would thus remain at approximately the same level.

This does not mean that other policies to induce a shift from driving to transit cannot succeed. It simply means that even a substantial gasoline tax will not make much difference.

Peak versus Off-Peak Effects

To the extent that a rise in the cost of driving causes a shift from driving to transit, most of the change would probably occur among commuters. But peak-hour transit service tends to be operated at saturation level already. If people shifted from driving to transit without a higher rush hour fare, commute service would become more crowded. Since transit patrons are quite sensitive to the comfort and convenience of travel, the decrease in the quality of the travel experience would deter the shift.

To avoid crowding and deterioration of service quality, a transit authority might add buses or trains. It costs from 2.4 to 3.6 times as much to add one bus on an existing route at a peak period as during an off-peak period (Morlok and Viton 1985, 250).[49] A transit authority loses more money on each peak period passenger than on off-peak passengers. A study of three California transit districts found that the cost-to-fare ratio per passenger mile is 25 percent to 50 percent higher at peak periods than off-peak (Cervero 1982b, 384).[50] Thus, just adding more capacity to accommodate more peak period passengers would be expensive and would accelerate the growth of the deficits of transit districts.

Raising peak period fares would be a far wiser option. In the three California transit districts mentioned above, the elasticity of transit fares at peak periods was less than half as large as the off-peak elasticity, which means that a rise in fares during rush hour would lose fewer passengers than a similar rise at other times of day (Cervero 1982a, 225).[51] The optimal fare differential (peak to nonpeak) was found to be 2.2 to 1 for the Los Angeles area, 1.33 to 1 for the East Bay (Oakland-Berkeley), and 1.5 to 1 for San Diego.

Raising rush hour transit fares and lowering off-peak fares to correspond with their relative marginal costs would increase equity in two ways. First, it would require peak and off-peak passengers to pay fares in proportion to the costs they impose on the system (but not the full cost unless all subsidies were eliminated). Second, passengers who ride during peak periods tend to be of higher income than those who ride during off-peak (Cervero 1982b, 388-89). Shifting costs to peak period passengers would thus be equitable in terms of ability to pay.

Raising peak period fares would encourage some changes in work hours and a reduction in nonwork trips during peak hours. Ridership during peak periods would be shifted to off-peak periods, which would make the transit system more efficient by balancing the load and shifting ridership to times of day when there is excess capacity in the system.

An increase in the price of gasoline might have more of an effect on ridership if it were combined with significant changes in transit fare structure. Specifically, local transit authorities should consider raising the price of travel during peak hours and lowering it during the rest of the day. Since price elasticity is lower at peak periods than at off-peak, the price shift would reduce transit deficits by shedding only a few passengers at times of high marginal cost and adding many passengers on trips of low marginal cost.

V. INDIRECT EFFECTS OF AN ENVIRONMENTAL TAX SHIFT

In addition to the direct effects of higher gasoline prices on driving (less driving in more fuel-efficient cars), there is also an indirect effect of some importance in the long run: land use decisions by households and businesses. Because huge amounts of capital are fixed by the existing form of cities, raising the cost of driving will make an observable difference only over time. Yet the low-density, auto-dependent structure of American cities today is in large part a result of low-cost urban transportation. A great deal of international and intrametropolitan evidence indicates that low-density suburban development promotes increased fuel consumption. Thus, if urban areas continue to decline in their overall density in coming decades, that will reduce the effectiveness of a tax shift in abating environmental damage. Policies that will slow or reverse the processes causing population dispersal should thus be considered.

A tax shift that raised the cost of driving would apply some new pressure to concentrate housing and jobs, and it could make low-cost labor more attractive by reducing the payroll tax—thus attracting new employers to urban areas. If the shift led to a large increase in the price of gasoline, it would be unlikely to raise urban densities noticeably in the short term, but it could possibly slow the existing rate of population dispersal. Future work by Redefining Progress will address the issues of tax shifting and urban form in more detail.

The Effect of Perceived Transportation Costs on Density

Whereas most policies that would bring about denser urban areas involve direct changes in land use, a tax shift that raised the cost of driving would apply indirect pressure to concentrate housing and jobs. A tax shift might not noticeably raise urban densities, but it would almost certainly slow the existing rate of population dispersal. The reason for this is simple: If the price of commuting and other urban travel rises substantially, some households will sacrifice the benefits of large dwellings at the urban fringe to live in somewhat smaller units closer to places of work and shopping. Since about half of the population moves to a different dwelling every five years (U.S. DOC 1993, 27), this adjustment process can begin in rather short order if people believe that a rise in costs is permanent.

The rise in gasoline prices would have to be high enough to have an appreciable effect on the overall cost of commuting. It would also have to be high enough to overcome the effects of rising incomes, which tend to reduce the concentration of population. Finally, it would be necessary to distinguish the effects of higher commuting costs from the growth of urban population, which also causes higher land values and thus higher population density.

No study has attempted to do all of that. Only a very large rise in fuel prices would cause the influence of commuting costs on land use to be large enough to be statistically detectable. Most studies that have examined the relationship of fuel prices on urban form in the United States have come to the conclusion that even the large increases in the 1970s were probably not sufficient to have made much difference.[52] (However, it is significant that the studies finding no effect were less empirically based than the ones that did find an effect.)

As one who argued against the likelihood of a locational effect of higher gasoline prices, Kursh noted that since gasoline prices rose only 4 percent per year faster than household incomes (from 1973 to 1979), and since gasoline accounted for about 3.8 percent of household spending, after six years the net increase in spending on gasoline amounted to only one percent of family income (Kursh 1980). Even that estimate is an upper bound because it incorrectly assumes that no change took place in fuel efficiency or distance traveled. For all but the lowest income households, the effect would not have had much impact on location decisions.

Muth (1984) makes a similar case that the jump in gasoline prices probably had little influence on choices of residence. He points out that commuting costs rose far less rapidly between 1973 and 1980 than the price of gasoline because other variable costs of driving fell. While gasoline prices almost doubled in real terms, other operating costs fell by 13 percent. The net effect was an increase in commuting costs of only 5 percent from 1973 to 1980. Real family income fell about 6 percent during the same period. But transportation costs are only about 20 percent of family income, so an increase of 5 percent of that base meant an increase in only 1 percent of family expenditures, confirming Kursh's figure.

Muth argues that the effects on commuters of the oil price increases of the 1970s were offset by a decline in other operating costs. Despite a doubling of gasoline prices, the total cost per mile of driving was only about 5 percent higher in 1980 than in 1973. If the value of time spent commuting is included in the calculation (with no increase in real incomes), the cost of driving an extra mile rose only 2.4 percent. Consequently, when the price of gasoline doubles, the average household would choose to live only 2.4 percent closer to the urban center than before the price rise.[53]

Based on Muth's model, there is little reason to expect a large increase in gasoline taxes to have any effect on urban density. However, actual response to the oil crises in 1973-74 and 1979-80 provides some evidence that urban location decisions may have been affected by the price of gasoline. From 1973 to 1976, the price at the pump for gasoline rose 50 percent, and there was speculation that prices would continue to rise. The anxiety about further price increases may have been as responsible as actual price increases for subsequent behavior. Empirical studies of changes in housing prices in specific urban areas during these periods indicate that the price of gasoline may be an important factor in decisions by households about where to live.

A study of housing values in Houston indicates that higher gasoline prices may have led people to look for housing closer to work (Smith and Ohsfeldt 1981). In 1970, families paid an extra 0.7 percent to live one mile closer to Houston's central business district. By 1976, that premium on proximity had jumped to 1.6 percent. In other words, people in Houston were willing to pay more for accessibility, even though real per capita incomes in the region had risen 33 percent—which should have reduced the density of population and the premium on accessibility. Smith and Ohsfeldt offer no explicit explanation for why the desire to live closer to downtown in 1976 had grown so much, but they note that "only seven years earlier commuting was so relatively effortless in Houston that accessibility premiums paid through the housing market were almost nonexistent" (p. 101). This suggests that an increase in the perceived cost of driving was responsible for this change in preferred levels of housing density. Presumably, as gasoline prices fell in the 1980s, this preference for accessibility declined.

Another study of three residential areas in the Philadelphia region shows that the sudden increase in the price of gasoline in the summer of 1979 had a differential effect on housing prices according to their location (Small 1986). There was no apparent change in prices in Society Hill, a high-income area located downtown, which already possessed a locational advantage; but the value of homes in Penn Valley—a high-income suburban area—fell as a result of increased commuting costs. Interestingly, the homes in Queen Village—a low-income area close to downtown—rose. Overall, there was a 66 percent jump in the ratio of housing prices of Queen Village and Penn Valley in May and June 1979. In effect, the prospect of lines at gas stations encouraged a very rapid increase in the gentrification of a poorer, downtown neighborhood. These results show clear empirical evidence that expected commuting costs can have an impact on urban form.

A useful model that accounts for changes in commuting and land use patterns was created by LeRoy and Sonstelie (1983). They show that 150 years ago, before motorized transportation, the rich preferred to live in the heart of cities and be close to their work. When streetcars and automobiles became available at a price only the rich could afford, professionals moved to the suburbs and commuted much greater distances than factory workers. Now that the relative cost of driving a car has declined, even many poor families commute to work by car. If the cost of owning and operating an automobile continues to fall, LeRoy and Sonstelie predict that the rich will reinhabit (gentrify) urban neighborhoods close to work centers.

If, on the other hand, high gasoline prices lead to a movement of urban populations toward the urban center, the process of gentrification of downtown neighborhoods would be reversed. Continuously rising gasoline prices would pull everyone toward the center, but it would pull the poor and middle class faster than the rich, because a rise in gasoline prices increases the cost of commuting (as a percent of income) for poor households faster than for rich households. That differentially encourages poor households to move into the urban core. A metropolitan area in which the poor are widely dispersed and are driving long distances to work would be much more affected than a city in which the poor are already concentrated near the central business district.

Effects on Telecommuting, Teleconferencing, and Other Information Services

The effect of gasoline prices on the geographic dispersal of metropolitan areas could be limited in the future by an increase in telecommuting, teleconferencing, and other uses of information technology. That is, if the rising price of gasoline discourages driving to some extent, the effect might be felt more in the adoption of information technology rather than in physical relocation.

As of 1991, approximately 5.5 million workers telecommuted at least part of each week (U.S. DOT 1993). This included people who commuted to regional centers or who commuted at off-peak times. About one-quarter telecommuted fewer than eight hours per week, another sixth telecommuted more than 35 hours a week; the remainder fell somewhere in the middle.

There is little hard evidence to date that would enable any predictions of whether businesses or households would increase the use of electronic communication as gasoline prices rose. Even if the use of that technology is completely insensitive to the price of gasoline, however, it might autonomously affect driving patterns. In other words, telecommuting and teleconferencing might cause reductions in commute driving without any change in the gasoline tax.

However, Mokhtarian (1988) points out that, in principle, telecommunication is likely to have conflicting effects on travel behavior. On the one hand, it is likely to substitute for driving to work and to meetings. On the other, it might encourage increased travel to participate in public activities that people learn about from the Internet. In addition, it might encourage people to live in more dispersed locations, which will increase the length of the trips they do make. One of the few empirical investigations of teleconferencing found that VMT actually increased by 29 percent for a regional meeting in Southern California that involved teleconferencing relative to other meetings that did not—due in large part to a higher level of attendance (Mokhtarian 1988, 288).

VI. LOCAL POLICIES TO COMPLEMENT A TAX SHIFT

A number of policies could be implemented at the state and local level that would reinforce the effects of a tax shift at the national level. Some of these policies would reduce the cost or increase the convenience of alternatives to driving, making a tax shift more politically feasible. Others would increase local driving costs where there are external costs specific to particular metropolitan regions.

Promotion of Alternative Forms of Transit

One local policy that could complement a tax shift would be to provide subsidies to para-transit and remove unnecessary restrictions on it. Para-transit refers to all forms of transportation other than private vehicles and standard forms of transit (heavy- and light-rail or fixed-route buses). It includes jitneys, airport vans, commuter vans, shared-ride taxis, dial-a-ride, and other specialized services. (Regular taxi service may also be classified as a form of para-transit.)

In most cities, services for special populations (e.g., the elderly and disabled) plus airport shuttles and commuter vans have arisen, although regulation may restrict supply. Generally, these services are not viewed as competing with the dominant forms of transit service.

In contrast, jitney services have been regulated out of existence in all but two U.S. cities—New York and Miami (Boyle 1994). In Asian, African, and Latin American cities, this form of para-transit is popular because it is cheaper, faster, and more flexible than large buses (Cervero 1997).

The primary obstacle to more widespread jitney operation in the United States is the concern on the part of transit agencies that jitneys will capture passengers from regular buses on the most profitable lines (short hauls through densely populated areas). This is known as "cream skimming." The problem actually lies in the fact that transit systems cross-subsidize inefficient routes in low-density suburban areas or during peak hours by generating excess revenue from efficient routes in off-peak periods. Jitneys appear to be unfair competition because they are not engaged in that sort of cross-subsidy. If cities allowed jitneys to operate, that would put pressure on transit agencies to develop pricing policies that reflected differential costs.

Even without any change in pricing policies, jitneys could be regulated in ways that enable both jitney operators and transit systems to be profitable. Since the marginal cost of bus service at peak periods is several times the cost at off-peak, it would be financially beneficial for transit systems to allow jitneys to operate at peak hours to reduce the need to add bus service.[54] This amounts to "deficit skimming" rather than "cream skimming"—higher deficits for peak periods than non-peak trips (Cervero 1997, 13; and Cervero 1988, 73-74).

A major problem of ordinary transit service is its inflexibility. Fixed-rail systems and large buses are effective at carrying large numbers of people between population centers or along heavily traveled routes. Outside of a few big cities (New York, in particular), little transit service is provided for off-peak shopping, eating, or other personal trips; even suburb-to-suburb commuting during peak hours is not well-served. Jitneys could offer consumers a service halfway between fixed-route bus service and taxis in terms of price and convenience. Families living in an area well-served by jitneys might choose to forgo an extra automobile.

Jitneys can also work in tandem with existing transit by providing a feeder service to bus stops and rail stations during commute hours. This makes transit more convenient and again may reduce the need for an extra automobile in some families.

If the jitney market is not regulated, however, a serious problem could ensue. Competition for passengers along heavily traveled routes can lead to a mutually destructive process known as "schedule jockeying," whereby one company registers its scheduled service just ahead of another company along the same route.

Fixed-route jitneys that do not operate on a defined schedule have an incentive to arrive at bus stops just ahead of the regular bus, thereby stealing passengers in whom the transit system has "invested" by establishing a scheduled service. To avoid this "arms race" while preserving the advantages of competition, a set of rules should be established—e.g., "curb rights," as described in Klein and Moore (1995a and 1995b)—that will fairly allocate the right to pick up passengers and protect the investments companies make in cultivating their clientele.

Opposition to jitneys is not just the standard response of a monopolist to any competition (though that remains the ultimate basis of resistance). A reasonable approach to para-transit is not whether to allow it, but under what conditions. By creating a market in curb rights, it should be possible to improve mobility for citizens and reduce reliance on automobiles for local transportation.

Congestion Pricing

Substantially higher gasoline prices would not consistently reduce driving. VMT would decline by 15 percent during the first decade of the tax hike, but by the end of two decades, rising incomes would cause travel to increase above current levels. Moreover, whatever effect a gasoline tax has on midday, weekend, and evening driving, it would have even less effect on peak period travel in the morning and late afternoon. Travel at peak periods is less price sensitive than off-peak travel; thus, a tax on gasoline will do little to reduce peak period congestion.

Such congestion is a problem in many cities because it imposes costs on drivers who lose time and become involved in excess accidents. By charging for the use of heavily traveled roads at peak periods, it should be possible to reduce these costs. In this regard, the 1990 National Personal Transportation Survey found that on a national level, half of morning peak period trips and about 70 percent of late afternoon trips are for nonwork purposes (US FHWA 1993, table 6.32).[55]

Several studies have been conducted to estimate the benefits to drivers of congestion pricing. In the Washington, DC, area, for example, Bhatt (1994, 78-79) has estimated that a charge averaging 15¢ per mile would reduce average round-trip commute times by ten to fifteen minutes by reducing peak travel 10 to 25 percent. Small (1992, 10) calculates that a similar charge in the Los Angeles area would reduce peak period traffic by 26 percent.[56] On the Bay Bridge connecting Oakland to San Francisco, an increase in the toll from $1 to $3 would reduce the number of morning peak vehicles crossing by 7 percent and reduce waiting time by 40 percent (Frick, Heminger, and Dittmar 1996, 34).[57]

Congestion pricing would raise enough revenue to contribute significantly to a tax shift at the local level. Bhatt (1994, 79) estimates that net revenues in Washington, DC, would be around $1.0 to $1.5 billion; Small (1992, 11) estimates net revenues for the Los Angeles area at $3.0 billion. Among the possible uses of that revenue would be offsetting the local taxes now raised to pay for transportation.

There are at least three general methods of implementing congestion pricing: traditional tollbooths, automatic vehicle identification (AVI), and zone fares. Full-scale implementation of congestion pricing throughout a metropolitan area is probably a decade off, since it would take a number of years to put the necessary equipment and administrative systems in place. While new highways and existing bridges could be fitted with equipment almost immediately, retrofitting existing highways would be a major undertaking.

The first—and oldest—method requires vehicles to stop at conventional tollbooths. For highways with a large number of entries and exits, tollbooths would need to be located on the highway itself, thereby slowing traffic and defeating the purpose of congestion pricing.

The second method, automatic vehicle identification, allows monitoring to occur while vehicles are in motion. AVI involves the use of sensors in or above the road that scan vehicles and charge their owners either by sending a bill in the mail or by debiting a prepaid card. This method of collecting tolls is currently being used on tollways or bridges near Dallas, New Orleans, Atlanta, Denver, Philadelphia, and New Jersey. All of these systems are on individual roads. None has revealed what difficulties would be faced if congestion pricing were applied to an entire metropolitan area.

The third method requires drivers to buy a sticker that serves as a license to use crowded roads at peak periods. That is similar to the "zone-pricing" method Singapore has used since 1975 to charge for access to the central business district during the morning commute hours (Lewis 1993, 103-5). The initial zone charge of S$5 per day reduced traffic in the central business district by 40 percent. In 1989, the charge was lowered to S$3 per day, and morning traffic has increased.

Parking Fees for Commuters

A more immediate and less technology-intensive solution to the problem of congestion would be to eliminate parking subsidies received by commuters. This method is not as effective as congestion pricing in targeting specific traffic problems, but it could function as a close approximation.

Currently, 90 to 95 percent of commuters do not pay to park (Shoup 1995, 14; and Shoup and Willson 1992, 1). Many urban employers pay the cost of employee parking as a fringe benefit, even though the employers often lease the parking spaces they provide, and could immediately cut costs by not offering this service. If employers offered employees a cash equivalent to the cost of providing parking, many employees would carpool, use transit, or perhaps telecommute more often.

The incentive effect of "cashing out" free parking would be almost as great as congestion pricing. Employer-provided parking valued at $3 to $6 per commute day amounts to a subsidy of 15¢ to 30¢ per mile for someone who commutes twenty miles round trip each day.[58] That is at least as great as the average congestion fee that has been proposed. Thus, if all employees were required to pay the full cost of parking, the effects on their use of carpooling and transit would be similar to congestion pricing.

Shoup and Willson (1992, 27) estimate that employer-paid parking in Los Angeles stimulates among employees a 44 percent increase in driving alone and a 33 percent increase in VMT during peak periods. Cashing out free parking would not actually reduce peak period driving by 33 percent, however. As noted above, about half of all peak-hour travel is for noncommute purposes, so—at best—cashing out would reduce peak period driving by about 15 percent. Even that is an overstatement of the effect of the policy, however. Without congestion pricing to complement parking charges, the reduction in commuters would probably be offset by an increase in driving for other purposes. The latent demand for driving at peak periods—people who now avoid driving at peak periods because of congestion—would be expressed. Thus, parking charges that apply to commuters should ideally be part of a policy that includes congestion fees.

Vehicle Insurance to Reflect Marginal Cost

At present, vehicle owners pay insurance premiums on the basis of the value of the vehicle, the location of their residence, and the age of drivers in the family. The amount a vehicle is driven is not factored into the formula. Yet the likelihood of an accident (and a claim against the insurance company) is presumably connected with the amount a vehicle is used.

Many vehicle owners fail to buy any kind of insurance. Those who do thus in effect contribute to a pool that is also used by those who do not. The current system also allows some seriously injured people to be undercompensated, encourages fraud in the form of inflated claims of pain and suffering, and is generally wasteful.

To remedy these flaws, a state could require that liability insurance be sold either as a surcharge on each gallon of gasoline or as a charge based on the number of miles a vehicle was driven in the previous year. The first approach (often called "pay-at-the-pump insurance") solves the problem of uninsured motorists but only roughly approximates a per mile charge on driving (Sugarman 1994).[59] (Since fuel efficiency varies, it charges higher insurance premiums for big vehicles out of proportion to the accidents they cause.) The second approach, which would require inspection of odometers at the time of vehicle registration, would impose precise per mile fees, but would not solve the problem of uninsured motorists as long as people fail to register their vehicles.

Both a per gallon and per mile fee to pay liability insurance premiums would have the effect of raising the variable cost of driving. Offsetting the higher variable cost, however, would be a lower fixed cost—the money now paid as a lump sum for insurance. Thus, on the one hand, the cost of vehicle ownership would decrease, making it more affordable to low-income families. The cost of driving, on the other hand, would increase.

If the pay-at-the-pump plan were adopted, it would reinforce the effect of a gasoline tax. In fact, to motorists, it would simply appear as one more tax. Its effect would thus be primarily to encourage more fuel efficiency.

The second alternative, the per mile charge, would have a somewhat different effect. By raising the price of driving but not the price of fuel, it would cause a reduction in VMT and have no effect on fuel efficiency. If the charge were set at 2¢ per mile, it would raise the variable cost of driving by about 20 percent. Although the effects of such a fee have not been modeled, it might reduce driving by an estimated 5 to 10 percent.

Location-Efficient Mortgages

In 1990, 36 million households owned two vehicles and 18 million owned three or more. Some of those households would willingly give up the extra vehicle if they did not feel it was necessary. That is likely to occur only for those families that live in sufficient proximity to stores and transit. Thus, one idea that has been proposed in recent years is the concept of location-efficient mortgages (LEMs) that would encourage families to trade off the cost of an extra car for the price of a more expensive urban dwelling near transit. The Center for Neighborhood Technology, Natural Resources Defense Council, and Surface Transportation Policy Project are jointly promoting this concept.[60]

The basic principle of an LEM is that it is designed to reward accessibility rather than mobility. With an LEM, a low- or moderate-income family could qualify for a higher value house in a densely populated neighborhood served by transit than would be possible under standard banking rules. Some of the money they would ordinarily spend on an extra car could be used to help pay off the mortgage.

Patrick Hare (1993) provides a simple example of how a reduced investment in vehicles can translate into a greater ability to pay off a mortgage. He estimates the annual cost of owning a second car at around $4,000. Subtracting $1,000 per year in transit fares (at $4 per day), he estimates that the total savings from not owning a second car is about $3,000 per year, or $250 per month. That is approximately equal to the payments on a $25,000 mortgage. In practical terms, a family that chooses to live in town instead of in the suburbs, and gives up one of its cars, could afford to buy a house worth $25,000 more than the amount a lending institution would normally calculate by its mortgage application procedures.

Hare's example is a bit too simple for actual banking purposes. John Holtzclaw has developed a more sophisticated methodology that permits quantification of automobile dependence on the basis of six factors: residential density, transit accessibility, neighborhood shopping, pedestrian accessibility, household income, and household size (Holtzclaw 1994). Using Holtzclaw's methodology, the Center for Neighborhood Technology, the Natural Resources Defense Council, and the Surface Transportation Policy Project have developed a formula they will try to persuade lenders to use in mortgage underwriting. Once some experiments have been conducted with LEMs, it might be appropriate for Congress to require the Federal National Mortgage Administration (Fannie Mae) to mandate their use.

The social benefit of location-efficient mortgages would be denser and less polluted cities, less congested highways, and more fully utilized transit systems that would require fewer subsidies.

Incentives for Brownfields Redevelopment

Contamination and abandonment of urban industrial property has been one reason for employment dispersal, which increases commuting distances and generally promotes travel in private vehicles by expanding the geographic size of metropolitan areas. Dispersal causes many employees who once used transit now to commute to work by car. A significant factor in the dispersal of manufacturing appears to be the avoidance of potential liability associated with these older industrial areas. States and regional agencies need to find ways to promote in-fill development by reclaiming these urban, contaminated areas commonly known as "brownfields."

There are two obstacles to the redevelopment of areas that may have suffered contamination: the chemicals themselves and the open-ended liability that any company faces if it takes over the property. Under federal and state laws, property must be remediated to a standard that is not clearly specified. The remediation process is long, drawn-out, and full of uncertainties. Moreover, the uncertainty of future costs is a major impediment to site redevelopment.

There is surprisingly little information on the amount and value of land that remains undeveloped because of liability issues. The one exception is a survey by the U.S. Conference of Mayors (USCM) of a sample of 39 cities with populations over 30,000. USCM gathered data on the number of brownfield sites in each of those cities, the acres involved, and the amount of property tax revenues lost (USCM 1996).[61] The cities varied considerably in the knowledge they possessed of the extent of contamination of industrial sites—with some just beginning site investigations and others having spent large sums on these already. Yet the survey estimates that 20,000 sites, covering almost 44,000 acres, are annually costing those cities between $121 million and $387 million in lost revenues. This estimate is almost certainly low, since some major cities—Houston, Denver, and Providence—had no cost estimates, and Chicago estimated only $1.4 million for five sites. The property value of the sites in the cities that did have estimates would be between $2.4 and $9.7 billion. If those cities are at all representative, a preliminary estimate of the aggregate loss of property values in all cities over 30,000 would be between $50 billion and $200 billion.[62]

There appears to be no simple solution to the problem of brownfields. The trade-offs between health costs and forgone economic opportunities are not clearly defined. Nevertheless, it appears that the strict liability standard may have become counterproductive. Rather than trying to punish offenders from the past, which was appropriate in cases of gross negligence at some of the worst-contaminated sites, federal and state policies should make the rebuilding of cities a much higher priority. New incentives for brownfields redevelopment—such as the one passed by Congress last year—are a first step toward making this a reality.

"Land-Value Capture"

The method by which transportation improvements (or existing operations) are financed can have an effect on the efficiency of the entire transportation system on a regional level. A tool known as land-value capture would not only minimize the need to subsidize transit systems with sales taxes, it would also increase pedestrianism and transit ridership by concentrating employment and residence near transit stops.

The basic concept of value capture is simple. It is based on the principle of recouping part of the windfall to property owners in the vicinity of new transit hubs. The increase in property values is most noticeable in downtown areas that attract large numbers of commuters and less visible in primarily residential areas. The transit system can pay part of its capital costs by charging a fee based on the increased value of property. The owner of the property then has an incentive to build more intensely on the site that has increased in value. The net result is higher density of commercial and office buildings within walking distance of transit. That, in turn, encourages more people to shift from driving to transit for their commuting and shopping trips.

There is considerable evidence that a large amount of revenue could be generated to cover the capital costs of transit systems in this way. Some of the subway lines of New York were, in effect, financed this way in the 1920s: the additional property tax on the newly opened land in parts of Brooklyn, the Bronx, and Queens was sufficient to pay the cost of the new lines (Law 1935).[63]

The rise in property values is not as great in already urbanized areas, but can still be dramatic. In a review of studies of value capture, Stopher finds that "increases on the order of one-third of the prior value per square foot of property, both developed and undeveloped, have been documented for some of these new transit facilities" (Stopher 1993, 236).

In recent decades, several metropolitan areas have adopted value capture as a method of partially financing rail transit, primarily through the 115 "joint development" agreements that have been negotiated (Cervero 1994). Under a joint development agreement, a private party agrees to pay the transit agency for part of the costs of building a station or part of the benefits received from combining a new rail station with a commercial building. (In some cases, the transit passenger must pass through a department store to go from the street to the train.) The private developer then receives a density bonus. One study estimated that the resulting additional development increased ridership by six transit trips per day for each 1,000 square feet of commercial floor space near a station (Keefer 1983). The attraction of a large retail development at one of Philadelphia's stations added $5 million per year in farebox revenues. Thus, the project not only pays part of the capital expenditures of the transit agency, but also adds to operating revenues.

The Los Angeles Metro Rail project, the most recent heavy-rail project built in the United States, adopted a different approach: creation of a benefit assessment district. Unlike joint development, this approach is aimed at collecting revenue from all businesses near stations that will benefit from the added foot traffic. Metro Rail was granted enabling legislation to issue bonds on the basis of projected revenue from benefit assessments. Because of restrictions on ad valorem taxes in California, the assessments were based on either land area or the gross floor area of office buildings. In 1986, the first taxes were levied on the assessments, and bonds were issued to pay part of the capital cost of the system from assessment revenues. Two years later, the courts declared the assessment procedures invalid because residential landowners had been exempted from the assessments. Nevertheless, the general principle of value capture through benefit assessments was upheld by the courts, paving the way for future uses if an equitable system can be established.

VII. CONCLUSION

The widespread availability of cheap fuel and affordable cars and light trucks has given Americans an unparalleled degree of mobility. That mobility has come with a price—one which motorists have not been required to pay in full. This report has estimated the unpaid cost imposed by motorists on third parties to be $184 billion—or about $1.60 per gallon of gasoline consumed. That cost does not include the $50 to $100 billion subsidy drivers receive in the form of free parking or the cross-subsidy among drivers that is caused by congestion. It is also a conservative estimate in other ways.

Phasing in an additional gasoline tax of $1.60 per gallon over ten years would offset much of the subsidy that driving now receives and encourage a number of changes in motorist behavior. Above all, it would encourage households to buy more fuel-efficient vehicles, perhaps two-thirds more efficient in the medium to long run. It would also reduce the amount of driving in each vehicle by 15 to 25 percent, but that would ultimately be offset by more vehicles on the road.

More expensive fuel would not significantly alter mobility patterns, although it might reduce total travel (VMT) by 14 percent. Transit ridership might rise slightly before continuing its downward trend, and carpooling would increase by perhaps 20 percent. But, on the whole, a large increase in the price of gasoline would not noticeably change Americans' heavy dependence on cars.

Reliance on private vehicles in the United States is largely dictated by urban form. American cities are characterized by a lower density than cities in most of the rest of the world. That accounts for much of the difference between Americans and Europeans in their driving behavior and use of transit. Those who hope to encourage a resurgence of reliance on transit should thus focus most of their attention on land-use issues, not on increased subsidies of transit systems.

To reduce the amount of traffic in U.S. cities, other approaches will be needed in conjunction with higher gasoline prices. Congestion charges and parking fees for commuters represent one set of policies that would complement a national tax shift by reducing local congestion. In addition to rationalizing the traffic patterns of a metropolitan area, these policies would generate large amounts of revenue—but they are not policies that can be pursued by the federal government.

Higher priced gasoline might have some effect on urban density, but not enough to resist the pressure for low density that results from higher incomes. Some local policies could be used to encourage higher urban densities; if pursued in conjunction with higher taxes on gasoline, their combined effects could stop the outward spread of cities and promote the creation of a transit- and pedestrian-friendly city.

This report has touched on a few policies that might have this effect. First, the provision of location-efficient mortgages could encourage more people to move into denser neighborhoods where they would not be as reliant on cars as they are in more distant and dispersed suburbs. Second, breaking the logjam surrounding the redevelopment of brownfields would open up large amounts of urban land that are currently being bypassed by industries relocating in suburbs or rural areas. The dispersal of housing will continue as long as the dispersal of jobs is also taking place. Third, an increase in the price of parking would raise the net cost of driving short distances above the cost of transit. The effect might be to encourage at least some people to live closer to work.

For 100 years, American society has gradually been turning over more and more space and authority to motor vehicles, reducing the potential of streets to serve as public space. The policies discussed in this report represent only the first steps toward reversing that trend. Taxation and land-use instruments, such as a tax shift, can begin to restore the balance between people and cars and thereby provide ways to address long-term problems such as climate change and congestion through new market mechanisms.

ENDNOTES

1. The government could provide groceries and manicures to everyone who wanted them, but that would not make these items public services.

2. This report focuses on the effects of a higher gasoline tax, but the same result could be achieved by auctioning permits for the right to sell gasoline. For simplicity, "tax" is used here to refer to any mechanism by which the price paid by consumers is raised.

3. The report also does not address the equity implications of an increase in the retail price of gasoline, since this issue is dealt with in Gilbert Metcalf,. "A Distributional Analysis of an Environmental Tax Shift" (San Francisco: Redefining Progress 1998).

4. A forthcoming paper from Redefining Progress may address issues of urban form in more detail.

5. The mere fact that most adults both drive and are harmed by air pollution or other damage caused by vehicles does not diminish the existence of a subsidy. It is driving, as an activity, that is subsidized—not the people involved. This might seem self-evident, but at least one analyst (Green 1995) has asserted that since vehicle users and citizens are the same set, all damage is "internalized." For example, Green argues that since most of the pedestrians hit by cars are also drivers or passengers at other times, damage to pedestrians should not be counted as an external cost of driving. The logical fallacy at work here involves the confusion of action and actor. In the role of drivers, people cause damage; in the role of pedestrians, people are hurt. The fact that the same people are in both sets does not deny the fact of external costs.

6. To my knowledge, no one has offered any evidence that there are any external benefits associated with the driving of private vehicles. A case might be made that greater private mobility has increased economic productivity, but that hypothesis has not been substantiated. Productivity gains achieved by private vehicles have been (1) captured by urban landowners in the form of higher rents, and (2) offset by increased transportation costs from population dispersal and longer travel distances.

7. User fees are fees paid for a specific service such as water or garbage disposal, while taxes are levies by which governments raise revenues without regard to who benefits. In this framework, charges on vehicles are clearly taxes. They can in no way be construed as user charges because they are not related to the use of any public facilities. (This is especially clear in the case of people who leave a car parked in the garage most of the time and rarely drive it.)

8. Since the purpose of this report is to estimate the effects of subsidies on driving, only factors that lower the cost of driving are included here, not ones that merely transfer resources among different groups within society. Not included are what some analysts (Apogee Research 1994; Greene and Duleep 1993; Lee 1995, 12; Litman 1995; and Miller and Moffett 1993, 16-23) have regarded as implied costs of or subsidies to driving related to (1) oil depletion allowances and other tax credits or deductions received by oil companies, (2) the macroeconomic effects of oil shocks, (3) the cost of the trade deficit due to imports of oil, or (4) delays due to traffic congestion. The first and third cases represent transfers (a shift of resources between individuals) rather than costs; the second is not sufficiently well-demonstrated to include; and the fourth represents a cost internal to drivers.

9. This calculation is based on the assumption that passenger vehicles continue to pay 71 percent of user fees, as estimated by FHWA (U.S. FHWA 1982, V-5) for 1985. Total user fees and tolls were $59.6 billion, so 71 percent would be $42.3 billion.

10. The 60 percent figure comes from an FHWA cost allocation study (U.S. FHWA 1982, V-5), which estimated the differential costs imposed by cars and trucks of various weight classes on the highway system as a whole. The study found that passenger vehicles impose around one-third of variable pavement costs and large trucks impose about two-thirds (p. IV-48). After fixed costs are taken into account, passenger vehicles account for an estimated 60 percent of the cost of roadways.

The estimate of $60 billion in annual replacement costs is a modified update (using the Producer Price Index for construction materials) of an estimate by Lee (1995, 12). Lee's estimate would be $78.8 billion in 1995 dollars. Since this figure is an imputation rather than a direct measure of a cost, I have chosen to treat the estimate with some caution and reduced it by about 25 percent (to $60 billion).

The 90 percent figure is a rough estimate based on the percentage of vehicle miles traveled by passenger vehicles, which was 91 percent in 1995 (U.S. FHWA 1997, V-92).

Finally, the $41 billion estimate of miscellaneous costs associated with highways is from U.S. FHWA (1995, table HF-10, errata sheet).

11. This approach is based loosely on the procedure followed by Miller and Moffett (1993, 8-9). They calculate the annual cost of providing roadways for cars and light trucks as $85.7 billion and the user fees from light vehicles as $21.5 billion (in 1990). Their estimate of the direct subsidy to passenger vehicles at the federal and state levels is thus $64 billion per year. They then add $8 billion in local subsidies, and arrive at a final estimate of $72 billion..

12. According to Hart (1986, 7-9), vehicle-related services provided by Pasadena in 1982-83 that are not included in the FHWA expenditure cost about $15.6 million (for a city of about 120,000); he extrapolates this to a national cost of $60 billion in 1982 dollars, or about $92 billion in 1995 dollars. Assigning this entire cost to motorists would, however, be unfair. Local streets add to the value of property in a community, and the property tax is—in effect—a user fee for access to streets. Nevertheless, it seems reasonable to assign some portion of the cost of these services to motorists. Of the elements compiled by Hart, only the cost of local streets (about 58 percent of Hart's total) can be assigned to property owners with confidence. The remaining 42 percent of costs might reasonably be assigned to driving, but since an unknown portion might increase property values, and since some of Hart's costs (such as fire department response to garage fires, and police investigation and court costs related to auto theft) are associated with auto ownership rather than driving, I have limited my estimate to 10 percent of Hart's $92 billion total.

13. The Strategic Petroleum Reserve is a stockpile of 568 million barrels of oil held in reserve for emergency purposes. Its cost includes both about $500 million in direct expenditures and another $500 million in opportunity costs (the interest that could be earned by selling the stockpiled oil and investing the money). Lee (1995) derives the 568 million barrel estimate from Pendleton (1992).

14. A $40 to $50 billion cost of projecting power into the Persian Gulf is derived from Delucchi and Murphy (1997, 33); this cost is assumed to be entirely oil-related. As in Delucchi and Murphy, it is assumed that half of the benefit goes to the stockholders of American oil companies and the other half ($20 to $25 billion) to the consumers of petroleum products. Since about 40 percent of petroleum is burned in the form of gasoline (derived from U.S. EPA 1996, appendix A), 40 percent of $20 and $25 billion in Persian Gulf military costs is assigned to passenger vehicle operation.

15. Using this approach, MacKenzie, Dower, and Chen (1992, 20) estimate the cost to nondrivers and nonpassengers as $55 billion, of which the largest portion was for pain, suffering, and loss of quality of life. Delucchi (1996, Table 1-8) estimates these costs as $13.1 billion to $49.0 billion. The basic source relied on by these and other recent analysts for information on the disaggregated cost of accidents is Miller (1991).

16. In one survey, the values from studies ranged from $1.6 million to $8.5 million in 1986 dollars (Fisher, Chestnut and Violette 1989, 98). In 1995 dollars, the geometric mean of the endpoints of the range is $5.1 million. In a more recent survey, the mean value of studies since 1987 was $7.0 million and the median $7.45 million (Viscusi 1993, 1926-27). Because a number of methodological issues remain unresolved, however, I have chosen a value toward the lower end from these surveys.

17. The number of reported fatalities of pedestrians and cyclists is not consistent among sources. The National Safety Council (1995, 82) estimates 7,200 fatal injuries of pedestrians and bicyclists in 1995 (6,300 pedestrians

and 900 cyclists); the National Highway Traffic Safety Administration (U.S. NHTSA 1996, 86) estimates a total of 6,524 fatalities of pedestrians and bicyclists, with no breakdown between the two categories.

18. The number of reported nonfatal injuries to pedestrians and bicyclists by the National Safety Council (1995, 82) was 103,000 in 1994. The National Highway Traffic Safety Administration (NHTSA) estimate was 145,000 (84,000 pedestrians and 61,000 cyclists); the agency estimates that 29,000 of those injuries were incapacitating (U.S. NHTSA 1996, 86).

Viscusi (1993, 1932-33) estimates the risk compensation value of all injuries as $25,000 to $50,000 per injury. The value of more serious injuries would be greater. Assuming around 100,000 injuries (as per the National Safety Council), and using Viscusi's upper-bound estimate, would impose a cost of around $5.2 billion. Alternatively, using NHTSA's disaggregated data, the value of incapacitating injuries is estimated at $100,000 and of other injuries at $20,000. Miller and Moffett (1993, 30) refer to several studies that estimate the willingness-to-pay to avoid serious injury as $100,000. Assigning a cost of $100,000 to the 29,000 incapacitating injuries identified by NHTSA and $20,000 to the other 116,000 injuries yields a cost of $5.2 billion.

19. Lee's estimate in 1991 dollars is $8.535 billion. In 1995 dollars, that amounts to $9.550 billion.

20. Electricity generation and industrial processes emit most of the remaining air pollution, except for coarse particulates (PM10 and larger), which come from agriculture and other sources.

21. The geometric mean is the square root of the product of two numbers, an especially useful way to deal with estimates that do not fall within a narrow range.

22. I have relied on the more conservative assumptions of McCubbin and Delucchi except in the case of the statistical value of life. They assign a range of values from $1 million to $4 million, and I have used an estimate toward the high end of that range. Thus, I have multiplied $2 million times their low estimate of what they call "acute non-harvest deaths," meaning people who die of acute respiratory or cardiovascular disease who were not already on the verge of dying. (This is lower than the statistical value of life in the case of accidents because the average age of "acute death" in the case of air pollution is higher than for accidents.) In the case of what they call "chronic deaths," meaning deaths that follow many years of chronic exposure, I assign a value of $1 million, which is well below the midpoint of their two estimates.

23. Delucchi et al. (1996, 51) estimate the net cost of crop damage from motor vehicle emissions at $2.2 to $4.2 billion, of which about 75 percent could be attributed to light passenger vehicles. They also estimate (p. 27) the cost of lost visibility from air pollution as between $4 and $26.5 billion if motor vehicles are solely responsible for visibility loss; or between $0.4 billion and $2.5 billion, assuming 10 percent of the loss were due to motor vehicle emissions. The geometric mean of the means of the two ranges is $3 billion—the value here assigned to visibility loss from vehicles.

24. This is known as the hedonic method of measuring social costs. Contingent valuation—asking people how much they would pay to reduce noise levels—has also been used.

Since damage from noise is estimated in lost property values, Green (1995) argues that vehicle noise should not be counted as a social cost. He notes that a person buying property where noise levels are already high pays less for it. But that is only a argument against compensating recent purchasers of property, as distinct from those who owned property prior to the current level of noise and vibration. It does not diminish the fact that drivers have exacted a transfer from landowners by lowering the value of property. Thus, drivers as a class still owe landowners as a class for the damage created by noise.

25. This range is derived from studies in Australia, Europe, the United States, and Canada. The estimates are actually from $0.001 to $0.006 per VMT, which translates to $2.4 billion to $14.4 billion under current conditions in the United States. Litman notes that, according to other sources, the cost of all transportation noise is around 0.2 percent of gross domestic product in the United States, Japan, Germany, France, and Norway. In the United States, that would amount to $15 billion, a figure that presumably includes airplane noise as well as street traffic.

26. This estimate is derived by estimating the total number of commercial parking spaces in the country, the cost of unit spaces in parking structures and in outdoor parking lots, and then estimating the number of each type. The average parking space requires 329 square feet, including access lanes (Shoup 1997, 22). Delucchi (1996) estimates that there are between 2,000 and 3,000 square miles of land devoted to parking in the United States. The midpoint of that range amounts to 1.6 million acres. Thus, there are 211 million parking spaces in the United States (132 spaces per acre times 1.6 million acres). If this estimate is correct, there are more parking spaces than vehicles in the country (190 million vehicles, according to U.S. DOC 1996, table 1003). That is not surprising, since several studies have found that both office and shopping center parking lots operate at about 50 percent of capacity (Shoup 1997, 2-3).

A suburban parking lot space of the sort found in a typical outdoor parking lot for a shopping center costs about $4,000 ($180 per year) per space for both land and improvements. Commercial land in suburbs costs between $3 and $15 per square foot or $1,000 to $5,000 per parking space for land cost. Construction costs and maintenance would raise that by $1,500 to $2,000 per space. At $4,000 per space total cost, that would amount to about $180 per year, assuming a fifty-year repayment. (These cost estimates, from architect David Mogavero, are for the suburban areas of Sacramento County. Since land prices are presumably higher than elsewhere in the country, I have chosen a low-end estimate of the cost.)

Shoup (1997, 5-8) estimates the cost of spaces in urban parking structures at around $1,500 per year ($23,600 capital cost plus $33 per month for operation and maintenance). Willson estimates the cost of a parking space in suburban parking structures at around half that ($12,300 capital cost plus operation and maintenance).

If 6 million spaces in the U.S. cost $1,500 per year, another 20 million cost $750 per year, and the remaining 195 million cost $180 per year, that amounts to $22.5 billion + $15 billion + $35.1 billion = $59.1 billion. The number of spaces in parking structures are pure guesses until better estimates can be found.

This is within the same order of magnitude as the estimate by Shoup (1992b, 28) that the employer parking subsidy amounts to $30 billion per year, assuming a value of $30 per month per space.

27. Whereas many of the social costs discussed above could be internalized through national fees involved in a tax shift, that would not make much sense for correcting the underpricing of parking. The effects of higher parking fees on driving behavior are therefore not considered here. It should be noted, nevertheless, that parking fees are perhaps the most effective way to change driving behavior. Since most trips in urban areas are ten miles or fewer, even a $1.00 parking fee doubles the price of such a trip. If other fees (to offset pollution and accident externalities) raised the perceived price of ten-mile trip from $1.00 to $2.00, the $1.00 parking fee would still add 50 percent to the cost, and higher fees than that are certainly normal in downtown areas.

28. According to Litman (1995), Saelensminde (1992) of the Norwegian Institute for Transportation Economics has estimated this cost at $0.01 per VMT, or about $22 billion in the United States in 1995. The Swedes and the Danes have also developed models for quantifying barrier effects of traffic.

29. The incremental unit might be quite large—perhaps one billion VMT in a year—if that unit is small relative to the total amount of driving done nationally.

30. Technically speaking, the tax rate would probably be somewhat lower than $1.60 per gallon. According to economic theory, the fee should be set at the marginal cost of the remaining damage after the charge has had a chance to reduce some of the damaging behavior. Since existing data do not permit analysis of marginal costs, before or after the charge, this level of refinement is not feasible. In practice, a tax would be phased in, and new information would permit a better approximation of the correct tax level over time.

In addition, the tax rate might need to be adjusted according to its actual effect on social costs. A gasoline tax is less than ideal in dealing with noise pollution and pedestrian fatalities. If more direct methods of internalizing those costs are found, the gasoline tax rate might be adjusted downward to compensate.

31. The delay can be handled by including earlier gasoline demand (a lagged endogenous model) or a variable representing the existing stock of vehicles which will continue to be driven for some years after a price change (a stock model).

32. This effect does not occur quickly. The median age of automobiles in use is about eight years, which means it takes around that long for half of the stock to turn over. However, older cars are often the second car for a family, and they are driven somewhat fewer miles per year than newer ones. As a result, about two-thirds of vehicle miles are driven in cars from one to eight years old (Davis and McFarlin 1996, tables 3.5 and 3.9). The full effect on fuel efficiency of a price increase in gasoline thus takes a decade or more to change the fuel efficiency of the entire stock of vehicles. Since this report examines long-run changes after the vehicle stock has had a chance to change, I have relied on estimates of the price elasticity of new vehicle fuel efficiency, which is higher than for the elasticity of the fuel efficiency of the vehicle stock as a whole. In addition, since the fuel efficiency gain resulting from the higher price of gasoline would exceed federal CAFE standards, those standards do not affect the results. The models I have relied on distinguish statistically between the effects of CAFE and the effects of prices on fuel efficiency.

    There may be a limit to fuel-efficiency gains, but huge advances are still possible. According to Lovins and Lovins (1995, 79-80) lightweight "hypercars," made of new composites that are more durable and safer than steel bodies, can achieve 200 to 600 miles per gallon. On that basis, they recommend incentives that will encourage a quantum leap in fuel efficiency, not the marginal changes that will be achieved by higher gasoline prices.

33. In each category, my estimate is simply the median of the estimates in the 1990s. I have excluded Dahl from the estimation process, since her results are primarily from studies in the 1970s and earlier. I have also included only one of the estimates by Sterner, Dahl, and Franzen: the time-series estimate for the U.S.

34. The price elasticity estimate in the table is the average of two estimates in Goodwin: an estimate from time-series studies of -0.71 and one from cross-section studies of -0.84.

35. Uses 1950 to 1994 data, and includes estimates for the effects of CAFE standards, the oil price shocks of 1974 and 1979, and a time trend. Schimek notes that he may have underestimated both price and income elasticities by assuming that the price of gasoline is exogenous, which may not be appropriate given the significance of the U.S. gasoline demand as a proportion of the total world market.

36. All of these estimates are based on lagged endogenous models. It is not surprising that the elasticity of demand in the U.S. should have a higher absolute value than in most European countries and Japan. Since gasoline prices are higher in the latter countries than in the U.S., gasoline consumption there is likely used more out of necessity and would not be as price-sensitive as in the U.S. Presumably, the finding of different price elasticities in different countries supersedes the statement by Dahl (1986, 74) that there is "little evidence that the long-run income and price elasticities change as income and prices increase over incomes ranging from Burma's to the United States' and prices ranging from $0.25 to $2.50 per gallon. Thus, to keep gasoline consumption constant in the long run would require real prices to increase somewhat faster than real income."

37. An unpublished "recent" study by analysts at the U.S. Department of Transportation, Volpe Center, cited in Schimek.

38. Two of the studies cited here indicate the price elasticity of fuel efficiency may only be as low as 0.2 or 0.3. Greene (1993) also estimates the elasticity in that range. Thus, it appears that the distribution of estimates of this variable may be bi-modal. There are several possible explanations, and it would be helpful if researchers in this field sorted them out. One is that the higher estimates have failed to take into account the effects of CAFE standards. Yet, the analysis by Nivola and Crandall, with results about halfway between the two poles of this distribution, indicate that CAFE makes only a slight difference in this estimate (0.43 vs. 0.39). Another possible difference is in the calculation of long-run and short-run estimates. A third possibility is that the lower estimates reflect the effect on the full stock of vehicles on the road, while the higher numbers reflect only the efficiency of new vehicles.

I am unable to resolve the apparent conflict. I have chosen an estimate from the high only in part because that is the median estimate. In this report, I am concerned with the kinds of changes that would occur over a decade if the price of gasoline rose several-fold. Under those circumstances, CAFE standards would become irrelevant and the ratchet effect referred to by Haughton and Sarkar (see next footnote) would take over. Thus, the high-end estimates of the elasticity of fuel efficiency seem appropriate for this study.

39. Haughton and Sarkar include CAFE standards in their model. Their actual estimates are ranges: price elasticity, 0.51 to 0.66; income elasticity, -0.03 to -0.09. According to the authors, this price elasticity applies only to increases in the real price above the previous peak. In other words, price rises have a permanent rachet effect that preserves efficiency gains even after prices fall again. "Having improved gasoline efficiency in response to a historically high price of gasoline, consumers will then remain at this point until the next exceptional price level comes around. A corollary is that it would require a large tax to have any effect on gasoline use per mile driven."

40. It appears that by "miles driven," Dahl may mean VMT by the entire stock of vehicles, not per vehicle. In that case, her estimate would combine the effects of both distance traveled per vehicle and number of vehicles in operation.

41. Goodwin estimates price elasticity as -0.29 to -0.33 (based on six studies).

42. Their estimate of income elasticity is a range: 0.24 to 0.31. I have chosen the midpoint.

43. The estimate in the table is for all light-duty vehicles. Nivola and Crandall also estimate the price and income elasticity of passenger cars as -0.30 and 0.54, respectively.

44. For a ten-year phase-in, the calculation is as follows: (1.28 times price elasticity) + (0.22 times income elasticity). If per capita income does not grow by 2 percent per year, the reductions in fuel use would be even more dramatic than those calculated. Per capita gross domestic product (GDP) grew 21 percent in the 1980s. That rate of growth has slowed in the 1990s, but might occur again. Per capita GDP is the relevant measure of income in this calculation because that is the variable used in most of the models that estimate income elasticity.

45. In addition, VMT per vehicle may have a lower income elasticity in the United States than international studies have suggested. Lave (1995) shows that the estimates of growth of VMT per vehicle in the 1990 Nationwide Personal Transportation Survey (NPTS) were biased upwards by the oversampling of new vehicles. Estimating the rate of growth of this factor shows a growth of VMT per vehicle of about 1.5 percent per year from 1983 to 1990. By comparison, NPTS implies a growth rate of 2.7 percent. If NPTS is adjusted for the growth rate in the other sources, the 1990 figure for VMT per vehicle is almost exactly the same as in 1969. This means that growth of VMT may be less influenced by rising income than our estimates imply and that a price rise will be more effective in reducing VMT than most models have predicted.

46. Although some factors (Europe's better public transit, higher urban densities, and lower per capita car ownership) would cause a simple comparison with Europe to overstate the potential effects of a gasoline tax, there is one factor which suggests the opposite. The growth of VMT in private vehicles rose 22 percent faster in Europe than in the United States from 1978 to 1993. If VMT had risen at the same rate as in the United States, fuel consumption there would have been lower, and the difference between America and Europe would have been even greater. That fact suggests that a higher fuel tax in the U.S. will have an even more pronounced effect on fuel use than it does in Europe.

47. The URL <http://www.publicpurpose.com/utus1920.htm> was the source of this information. The Public Purpose is a website provided by Wendell Cox, a transportation and demographics consultant.

48. A 127 percent rise in gasoline prices would lead to a 32 percent increase in the number of transit trips in the absence of income growth (assuming a cross-elasticity of 0.25). If the income elasticity of transit trips is -1.0 (or perhaps even greater), a 20 percent income gain would reduce ridership by 20 percent or more, thereby eliminating all but 12 percent of the gains from higher gasoline prices.

49. The 3.6 estimate comes from Chicago, and the 2.4 estimate is from Bradford, England. Peak-hour service costs far more to deliver because it is necessary to build excess capacity into the physical stock (buses, trains) and into the labor force to accommodate demands. This is the same situation faced by electric utilities that have to have idle capacity during off-peak periods available for peak-load demands.

50. These estimates are for average costs, not marginal costs. If the latter were used, the difference would undoubtedly be more extreme, since the marginal cost of filling unused capacity during off-peak hours is virtually zero. That is, riders at off-peak periods already cross-subsidize those who ride at peak periods.

51. In the Los Angeles region, for example, the peak period fare elasticity was -0.07 and the off-peak elasticity was -0.24, more than three times greater. In the East San Francisco Bay Area, the comparable elasticities were -0.15 and -0.36; in San Diego, they were -0.18 and -0.46. Cervero (1985, 124) also points out that higher peak fares might lead to large decreases in ridership if the quality of service is not perceived to merit the price. He notes that service elasticities are twice as large as fare elasticities. (This would be less important, however, if the cost of driving were also much higher, making the latter alternative less attractive.)

52. This is in fact what one would expect from the evidence presented earlier that shows the primary response to higher fuel prices is the purchase of more efficient vehicles rather than reduced driving. Residential location decisions would be affected in relation to the total cost of driving, not just the price of gasoline. If the cost per mile of driving rises more slowly than cost per gallon of gasoline, that reduces incentive to choose to live in a residential area closer to work. Authors who found little evidence that a rise in gasoline prices had an influence on location decisions include Bruce-Riggs (1974), Keyes (1980), and Small (1980).

53. Muth (1984, Tables 4 and 5) calculates commuting costs as about 2.5 percent of housing costs in 1973 and 1980, assuming housing costs to have been stable. Some commuters spend more time and money driving to work to gain cheaper housing. Others will pay more to live close to work. One would then expect, in a city in which most commuting was from suburbs to the central business district (CBD) that housing costs would decrease by approximately 2.5 percent for each additional mile from the CBD. The rise in commuting costs would change the tradeoff and slightly increase the advantage of living closer to the CBD. (The greater the attraction from outer suburbs to inner suburbs and the central city, the bigger the differential or rent gradient.) According to Muth's calculation, the gasoline price rise of the 1970s raised the differential between closer and more distant homes from 2.47 percent per mile to 2.65 percent per mile, a 7.3 percent rise in the differential. Including the declining cost of operating a motor vehicle (which offset the rising price of gasoline) diminished the differential to only a 2.4 percent change from 2.47 to 2.53 percent per mile.

That calculation assumed constant incomes (which is what occurred in the 1970s). If incomes and housing costs had risen 2 percent per year in the 1970s, and commuting costs had remained constant, Muth calculates the per mile differential in the commute/housing cost ratio would have fallen from 2.47 percent per mile to 2.27, an 8 percent drop. (City prices would be falling relative to suburban land prices, which would be rising as demand for housing shifted outward.) Since the doubling of gasoline prices with no increase in income caused the differential to rise by 7.3 percent, the prevention of further decentralization of urban areas would require more than doubling the real price of gasoline each decade to offset the 8 percent drop that occurs with a 2 percent annual rise in real incomes.

54. As noted earlier, the deficit per passenger mile is 25 percent to 50 percent higher at peak periods than off-peak (Cervero 1982b, 384). If public transit agencies were operated on the model of a private enterprise, they would welcome the removal of the passengers who impose the highest costs. Instead, agencies seek to maximize their budgets and their service areas and to avoid all competition—even competition that would hold their costs down.

55. Shoup (1995, 15) estimates that work trips account for 64 percent of morning peak-period automobile trips, which would mean that 36 percent are for nonwork purposes. I have been unable to determine the source of the difference between his estimate and the one in the Nationwide Personal Transportation Survey.

56. Small's analysis is based on Cameron (1991).

57. The toll was in fact increased to $2 in late 1997.

58. Shoup (1997, 7) estimates the average cost of a space in an urban parking structure to be $124 per month. That amounts to $5 to $6 per commute day. Willson (1995, 39) estimates the value of a suburban parking space to be about half as great. The average commute in 1990 was about twenty miles round trip (U.S. FHWA 1994, 3-16). About 10 percent of commute trips are fifty miles round trip or greater.

59. Sugarman (p. 365) proposes that: "Additional charges would be imposed on drivers according to their driving record and their experience. Good drivers age 20 and over would contribute at the rate of $20 a year, payable when they renew their driver's licenses. Drivers with bad records, young drivers, and novice drivers would pay more, in some cases at least $500 more." Finally, he proposes that an additional fee be paid when registering vehicles, based on the safety record of the vehicle. In his plan, the fuel-based fee would be 30¢ per gallon of gasoline.

60. The best information on this subject is available on the Internet at <http://www.cnt.org/lem>.

61. The cities that responded, including Chicago, Houston, Detroit, San Francisco, Seattle, Cleveland, Denver, St. Louis, Tulsa, Louisville, Birmingham, and Rochester, have a combined population of around 11 million people, or about 10 percent of the U.S. population in places over 30,000.

62. The effects of land abandonment can be devastating to a city. Consider the case of St. Louis. According to Freeman Bosley, Jr., the mayor of St. Louis (in 1996), 15 percent of the land in that city has been acquired by its Land Reutilization Authority as a result of abandonment by private owners (USCM 1996). Furthermore, one-third of privately held land in St. Louis is underutilized because owners cannot develop land fully as a result of environmental restrictions. Much of the land cannot be redeveloped because the cost of remediation exceeds the value of the parcel after decontamination. Mayor Bosley described one retail site where the city paid $26.25 per square foot to reclaim a site that now has a value of only $2.00 per square foot. In another case, it paid $6.00 per square foot for industrial land that was ultimately worth only $1.50 per square foot. If those situations are representative, large tracts of St. Louis will remain abandoned until remediation standards are modified or the value of central location increases.

63. Referring to the Roosevelt Avenue line in Queens, Law said: "If we apply to this yearly increase (in property values) due to the increased transit facilities, the average tax rate of $2.70 per $100 we find that the tax return over a period of 10 years was $11,150,000 per square mile, which has more than paid for the original cost of the construction of this line. A careful analysis shows this to be true of the construction of all other lines through previously undeveloped areas in the City."

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