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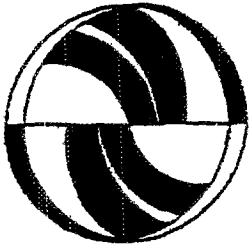
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**Economics and Urban Transportation Policy
in the United States**

Kenneth A. Small

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Economics and urban transportation policy in the United States

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Economics and urban transportation policy in the United States

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Abstract

This article examines the role that economics can play in analysing problems with urban transportation in the United States. The specific problems addressed are failing infrastructure, financially weak public transit, environmental impacts of motor vehicles, motor-vehicle accidents, and traffic congestion. Simple quantitative analyses, even though approximate, can help to focus attention on the most promising classes of policies. Those classes involve some technological measures and some narrowly targeted behavioral changes, but not the widespread curtailment of motor vehicle use. © 1997 Elsevier Science B.V.

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JEL classification: R40, H23

1. 1. Introduction

Economic arguments often play an important role in the formulation of transportation policy. For example, economists have greatly influenced regulatory policy in the United States, as documented by Winston (1993). This has encouraged widespread deregulation of intercity transportation services, as well as a number of other industries, over the past twenty years. While urban transportation has been less influenced by this movement than has intercity transportation, it

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has by no means been exempt, as exemplified by experiments with bus deregulation, privatization of transit services, and road pricing

In examining the deregulation of intercity transportation, Winston emphasizes the role of quantitative calculations in persuading policy makers to adopt reform. He also examines the role of sophistication in model building, finding that the predictive accuracy of the economic analyses that were done depended not on the complexity of the analytical models used, but on whether or not major structural adjustments (such as the development of hub and spoke air networks) were anticipated and included in the models. Thus it is often the incisiveness of the economic insight, not the completeness of its elaboration, that is most crucial. Furthermore, the persuasiveness of economic analysis to policy makers may depend more on the credibility of such simple arguments than on the more complex modeling efforts that quite rightly influence professionals.

In this paper, I examine how economic analysis can elucidate some well-known problems of urban transportation in the United States: (1) failing infrastructure, (2) financially weak public transit; (3) environmental impacts of transportation, (4) motor-vehicle accidents, and (5) traffic congestion. In each case I argue that basic economic arguments can help steer policy away from unproductive directions. Furthermore, relatively simple quantitative calculations can play an important role in understanding some of these problems and in defining the categories of potential policy responses to them that are most promising.

2. Failing infrastructure

Winston and Bosworth (1992) provide an insightful survey of the state of U.S. public infrastructure. Over the past two decades, the nation has seen a sharp decline in the percentage of its gross national product (GNP) devoted to gross investment in infrastructure, from nearly four percent in the late 1960s to $2\frac{1}{4}$ percent in 1990. The total value of the capital stock has declined similarly as a percentage of national product, from 49 percent of GNP in 1970 to 41 percent in 1990. These declines have occurred “at all levels of government and .. across a broad range of different types of capital” (Winston and Bosworth, 1992, p. 268). One of the largest categories affected by these trends is transportation infrastructure, especially roads, and one of the most visible manifestations of these trends is the physical deterioration of highways, bridges, and subways.

Some of these declines are natural reductions from a peak in infrastructure expenditures that occurred during the 1960s due to rapidly increasing school enrollments, suburbanization, and the beginning of an ambitious interstate highway system. Nevertheless, there is considerable evidence that improving the public infrastructure would now have a high rate of return. This evidence includes macroeconomic studies of the relationship between public infrastructure and productivity (Munnell, 1992) and microeconomic studies of the costs and benefits

of specific investments (U.S. Congressional Budget Office, 1988). Gramlich (1994) provides a cautious and insightful review of evidence and policy implications.

A conclusion drawn by many is that the United States needs to spend more on public infrastructure. In fact, the nation is already moving in that direction since its low point in the early 1980s, investment in public infrastructure has risen, as a fraction of GNP, from 2.0 percent to about 2.25 percent, core infrastructure spending in particular has increased substantially in real terms, from about \$21 billion to \$32 billion (1992 dollars) in the case of roads.¹ For highways and bridges, it seems that current spending levels, if maintained as a fraction of GNP, would be sufficient to maintain conditions as they were in 1989. This still leaves some significant deficiencies, but at least is a better prognosis than a few years ago. The most recent federal highway legislation, the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, should continue and perhaps accelerate the trend toward larger capital expenditures on highways.

However, there is little guarantee that these new expenditures will be targeted to those measures that are most useful. A large portion of new spending in ISTEA is for special highway projects, a category heavily dependent on political considerations and with a poor track record (Winston and Bosworth, 1992, p. 287). High federal shares and biases in favor of capital intensive projects have been demonstrated to cause inefficiencies in a variety of types of infrastructure projects, especially mass transit. Often projects are distributed widely in order to achieve a politically viable distribution of expenditures, rather than targeted to those areas where rates of return are highest.

Furthermore, pricing policies often cause infrastructure to be built to accommodate inefficient numbers and mixes of users (Winston, 1991). In the case of highways, capacity must accommodate peak traffic volumes that are unrestrained by any significant pricing, these volumes are further inflated by employer-provided parking subsidies, which are in turn strongly encouraged by the federal tax code and by many municipal planning ordinances (Willson and Shoup, 1990). Furthermore, a lack of pricing incentives on heavy trucks causes them to impose damage to pavements that could be greatly reduced with relatively inexpensive reconfigurations of their axles (Small et al., 1989). In the case of airports, landing fees that bear little relationship to use of scarce peak runway capacity result in too many flights at peak hours and too many small private airplanes clogging the busiest commercial airports (Morrison and Winston, 1989).

Research suggests that optimizing investment strategies and better managing the infrastructure through pricing can create measurable and very large reductions in the cost of providing any given level of infrastructure services. For example, Small

¹Winston and Bosworth (1992), Figs. 8-1, 8-2, inflated to 1992 prices using consumer price index for all items, from U.S. Bureau of the Census (1993), table 756.

et al. (1989, p. 53) identify annual cost reductions for the US road system, excluding bridges, that amount to \$11.3 billion at 1992 prices. Therefore the effective amount of useful infrastructure can be substantially increased without necessarily increasing the long-run costs of investment.

3. Financially pressed mass transit

Mass transit service in the United States, poor as it is compared to Europe, absorbs enormous subsidies — about \$13.5 billion in 1993, roughly a twelve-fold increase in real terms since 1970.² About half of this increase occurred during the 1970s and was a source of local and state fiscal crises (Pickrell, 1983).

Transit subsidies have attracted considerable attention from professional economists, and as a direct result the ingredients for understanding this phenomenon are at hand. First and foremost, as Mohring (1972) has shown, public transit (like any service performed in batches) is subject to sharply increasing returns to scale when one takes into account the value to users of higher route density and service frequency. If demand on a particular corridor rises, the transit provider serving that corridor can respond in one of several ways. If vehicles are not fully occupied, or if larger vehicles can be operated at little additional cost, the provider might choose to handle the extra passengers simply by maintaining the same routes with the same service frequency, allowing average cost to decline. Alternatively, the provider can increase route density and/or service frequency, which produces cost savings to passengers in the form of less walking or waiting time. In either case, total average cost (to provider and users) declines. A different way of putting the same point is that given a particular level of service, as measured by the density of routes and the frequency of vehicles on a given route, handling an additional passenger costs little extra because it does not necessitate extra vehicles or drivers. From the point of view of economic theory, this is the primary justification for transit subsidies. Nash (1988) offers a clear formal exposition of this argument and an enlightening application of it to policy toward privatization of transit.

This property of increasing returns to scale, however, greatly limits the viability of mass transit in the United States because population density there is so low. For example, the US population is about the same as the combined populations of Germany, Italy, the U.K., and France, but it occupies more than six times the area (US Bureau of the Census, 1995, table 1361). It is no surprise that this relative

²The figure quoted is total expenses minus operating revenues, from US Bureau of the Census (1995, table 1046) and (1981, table 1101). The twelve-fold increase is calculated after deflating by the consumer price index for all items, from US Bureau of the Census (1995), table 761.

abundance of land is reflected in lower urban densities,³ although of course history also plays a role in that comparison. In addition the U.S., like other nations, has seen the automobile capture a rapidly increasing share of trips. This exacerbates the difficulty in finding corridors with passenger densities suitable for successful mass transit service.

Failing to recognize these facts, policy makers in the United States have tried to increase transit patronage by expanding transit service far into suburban areas precisely where it has the least market potential. Meanwhile, they have failed to take full advantage of two of transit's most natural markets (Meyer and Gomez-Ibanez, 1981, ch. 3): low-income inner-city residents, who have been relatively neglected as a market, and high-income commuters to central business districts, who have been served by building new rail transit lines, an extraordinarily expensive method in most locations where it has been adopted in recent years. The results have been disappointing ridership and debilitating subsidies. Furthermore, the subsidies appear to have encouraged dramatic increases in management personnel and in union wage rates, simultaneous with a substantial fall in labor productivity as measured, for example, by vehicle-hours per driver-hour (Pickrell, 1983; Lave, 1991).

One possible response to high subsidy costs is to radically change the institutional structure of mass transit through privatization. Economists have taken an active and constructive role in analyzing private markets for mass transit services and in predicting the impacts of various proposals (see Small, 1992, pp. 143–151, for a review). A wide variety of experiments in Britain, the United States, and elsewhere are providing a wealth of data to test these ideas (Dodgson, 1991; Talvitie et al., 1991; Banister et al., 1992; Gomez-Ibanez and Meyer, 1993; White, 1995). While economists are far from reaching consensus on all the details, this work has narrowed the range of controversy considerably, mainly to how extensively and in just what contractual form private firms should be brought into the picture. For example, debate continues on how successful deregulation of British bus transit has been, but it is widely agreed that it has lowered costs and that competitive tendering for services, as practiced in London, reaps many if not all of the cost savings of more complete deregulation. It is also widely agreed that bus transit is not a perfectly contestable industry, leaving at least some scope for monopoly pricing under full deregulation.

³Definitive comparisons of urban densities are impossible due to the difficulty of defining comparable urban areas. One attempt is made by U.S. Bureau of the Census (1993, table 1377), which defines an urban area as a continuous built-up area including locations with population density at least 5000 per square mile. Among the world's 50 most populous urban areas by this criterion, those in Europe and the United States had 1992 population densities (in thousands per square mile) averaging 27.2 and 9.4, respectively. The densities of the individual cities, in decreasing order of total population, were: New York (11.5), Moscow (27.8), Los Angeles (9.1), London (10.5), Paris (19.9), Essen (10.7), Chicago (8.5), Milan (13.7), St. Petersburg (33.4), Madrid (69.3), Barcelona (48.5), San Francisco (9.4), Manchester (11.2), and Philadelphia (8.4).

Another possible response is to shift the responsibility for providing transit subsidies to local governments, in hopes that local taxpayers will discipline the transit agencies to provide only cost-effective services. Economists could be more proactive here by further developing techniques to weigh the theoretical benefits of subsidies against the leakage of benefits that can occur, due for example to the high marginal cost of raising public funds or to wasteful expenditures.

One distributional consideration is especially in need of more economic evaluation. How should we transport people who cannot drive? With the leading edge of the U.S. "baby boom" now hitting 50 years of age, it will not be long before that question takes on greater prominence.

Table 1
Some typical short-run average variable social costs of urban automobile travel: United States, 1992

Type of Cost	Cost (\$ per vehicle-mile in 1992 U.S. prices)
(1) Running costs	0.075
(2) Vehicle capital	0.204
(3) Time	0.152
(4) Schedule delay	0.083
(5) Accidents	0.110
(6) Parking (CBD fringe)	0.150
Total	
Without parking	0.624
With parking	0.774

Source: Small (1992), table 3.2, p. 84, revised as follows.

(1,2,6) 1989 prices are here updated to 1992 prices using consumer price index components for private transportation (categories 1 and 6) or new vehicles (category 2), from U.S. Bureau of the Census (1993), table 758. (Taxes are excluded. Parking cost assumes a 17-mile round trip.)

(3) Wage rate is here taken as average 1992 wages and salaries per hour worked, private industry workers [\$11.58 per hour, from U.S. Bureau of the Census (1993), table 677], adjusted by the ratio of metropolitan to all-U.S. average annual pay [1.047, from U.S. Bureau of the Census (1993), table 670]. (Figures are for single occupant, valued at half the wage rate, assuming speed 40 miles/hr.)

(4) Updated to reflect the higher value of time (\$6.06 per hour) implied by note (3) compared to that (\$4.80) used in Small (1992). (Schedule delay cost is the inconvenience of arriving at work before or after the preferred time, estimated at the equivalent of 7 minutes of travel time per one-way trip for the average member of a sample of commuters to San Francisco and Oakland, California. Per-mile value assumes one-way trip length of 8.5 miles.)

(5) Accident costs in Small (1992) were for 1980 accident rates, expressed in 1989 prices, assuming a 1989 value of life of \$4.0 million. They include administrative costs of the insurance system. Here they are adjusted for the ratio of 1992 to 1980 fatality rates [0.55, from U.S. Bureau of the Census (1995), table 1033], and for the ratio of 1992 to 1989 hourly earnings [\$11.58/\$10.38, from U.S. Bureau of the Census (1993, table 677) and (1991, table 684)] to reflect the presumed increase in value of life and injury.

4. Environmental effects of transportation

The effects of transportation on the environment constitute an enormous subject with a high political profile. It is treated, for example, by Banister and Button (1993). Perhaps in no other area of transportation policy have writers discussed so passionately the role of motor vehicles.

In order to provide a quantitative background for this and the next two problems considered, I list in Table 1 some estimates of typical costs of driving an automobile in urban areas in the United States. The figures are intended to represent average social costs, they therefore exclude taxes and the marginal externality costs associated with congestion. They also exclude environmental costs, due to the great uncertainties in estimating them. However, several quite sophisticated studies attempt to estimate certain categories of environmental costs, notably air pollution and global warming. The argument that follows is restricted to these two categories of environmental effects.

Estimates of air pollution costs use a variety of methods including direct assessment of health costs, statistical correlations between air pollution and mortality, surveys asking people how much they value specifically described environmental amenities, and statistical studies relating air pollution to residential property values. The resulting implications for aggregate costs from the pollution caused by gasoline-powered vehicles in the United States appear to be on the order of \$10–50 billion per year for the early 1990s.⁴ This is approximately \$0.007 to \$0.037 per vehicle-mile, or roughly \$900 to \$4400 over the life of each car.⁵

⁴This is my assessment of the most reasonable range for damages resulting from all emissions of carbon monoxide, hydrocarbons, and nitrogen oxides (including secondary products such as ozone), which may be taken as roughly representing the problems caused by gasoline-powered vehicles. The figures given are roughly the central values found in a variety of often conflicting studies. For example, Small, 1977, estimates 1970 U.S. costs from these pollutants at \$5.38 billion, but uses a value of life substantially lower than current estimates based on labor-market behavior toward risk (Small, 1992, p. 83). U.S. Federal Highway Administration, 1982, p. E-47, uses estimates, derived from Haugaard, 1981, that sum to \$25 billion for 1981. Krupnick and Portney, 1991, p. 524, on the other hand, estimate only \$0.25 to \$1.0 billion in benefits from a 35 percent reduction in reactive hydrocarbon emissions. The Los Angeles region, where ozone is a serious automotive-related air-quality problem, typically accounts for a substantial fraction of such estimates, recent estimates of the health costs of exceeding the federal ozone standards in the Los Angeles region range from \$0.3 billion (Krupnick and Portney, 1991) to \$2.7 billion (Hall et al., 1992; Small and Kazimi, 1995).

⁵Based on the assumption that all economic damages are from emissions in urban areas, and the estimate of 1363 billion vehicle-miles of urban travel in 1992 [AAMA (1995), p. 65]. I also assume average vehicle lifetime mileage of 120,000 miles, this is a downward adjustment from what would be calculated from the average vehicle usage of 12,458 miles (*ibid.*, p. 64) and an average vehicle life of 12 years, which is the median retirement age of a 1979 model car as calculated from *ibid.*, p. 39, the adjustment being required because newer cars are more numerous in the vehicle population and are driven more than older cars. Small and Kazimi (1995) estimate the costs of automotive emissions in Southern California, whose population density, topography, and climate make pollution especially severe, to be \$0.03 per mile using mid-range assumptions.

Clearly these magnitudes allow for the possibility that a noticeable increase in the price of a car could be justified for technology that eliminated many of these costs. On the other hand, the per-mile cost estimates are not very large compared to those categories reported in Table 1 that are now privately borne, charging externality taxes based on these estimates would therefore not make much change in the overall private cost of driving, so would not induce much reduction in automobile use.

Global warming due to the greenhouse effect is more difficult to analyze because the magnitude of the effects are so dependent on poorly understood scientific relationships, and the chief economic impacts are far in the future. Cline (1991) and Nordhaus (1991b) provide excellent reviews. It is clear that current carbon dioxide emissions may disrupt the future climate, but any cost estimates are highly speculative. Instead of using such cost estimates, I consider estimates of the shadow value of carbon dioxide emissions in scenarios where political decisions require specified reductions. The reductions considered are substantially more stringent than any decisions taken so far.

Nordhaus (1991a, p. 50) finds that a policy that reduces carbon dioxide emissions by 50 percent from their projected base path, at each point in time, would entail a marginal cost of carbon abatement in the neighborhood of \$143 per ton (\$0.16 per kilogram) of carbon removed. This is nearly twice as large as a carbon tax that was proposed in the European Community in 1991 (Du Bois, 1992). Manne and Richels (1992, pp. 51, 59, 60) estimate the marginal value of emission rights that would prevail in a rather different curtailment scenario: one in which the U.S. maintains its carbon dioxide emissions at their 1990 rate for ten years, reduces them gradually to 80 percent of that rate during the next ten years, then stabilizes them at that lower level. The shadow value begins at about \$140 per ton carbon, then oscillates and eventually stabilizes at \$208 per ton. Cline (1992, pp. 54–61) finds this to be near the upper end of the range of values produced by several models reviewed.

I therefore take \$140–\$208 per ton (1990 prices) as representing a reasonable range of estimates of the shadow value of carbon emissions under foreseeable international agreements or domestic political decisions. Updated to 1992 prices, these figures are equivalent to \$0.45–\$0.67 per gallon of gasoline, or \$0.021–\$0.031 per vehicle-mile.⁶ This is similar to the range quoted above for the costs of conventional air pollution.

What would happen if these estimated social costs of pollution and shadow value of carbon dioxide emissions were charged to users through fuel taxes? Doing so would raise the average fuel tax within the United States by \$0.63–\$1.50 per

⁶Based on one ton carbon content for every 335 gal refined petroleum product, calculated from Manne and Richels (1992), p. 59, and 1992 average fuel consumption of 1 gal per 21.7 miles, from U.S. Bureau of the Census (1995) table 1042. Prices are deflated by the consumer price index for all items, from U.S. Bureau of the Census (1995), table 761.

gallon,⁷ a sharp increase from its current value of about \$0.35 per gallon (U.S. Bureau of the Census, 1993, table 1015). Nevertheless, it would leave U.S. fuel taxes well below most European levels (Pucher, 1988). European fuel taxes, while no doubt curtailing automobile use somewhat, have not prevented it from growing at about twice the U.S. rate for two decades (Pucher, 1995).

These cost estimates, then, crude as they are, support two conclusions. First, people place a high value on the environmental impacts of motor vehicles, as measured by willingness-to-pay to reduce the known health effects and to adopt measures to forestall the unknown but potentially devastating climatic effects. But second, this value appears to be well below that which would indicate a willingness to reverse the longstanding shift toward high levels of automobile ownership and use. Substantial expenditures to reduce air emissions from automobiles may be justified by quantitative economic analysis, but draconian measures to reduce the use of motor vehicles are not.

Fortunately, there is no real dilemma in this position. Direct measures, both technological and behavioral, exist which could greatly reduce the environmental effects of motor vehicles without having much effect on their overall use. For example, there is strong evidence that a small fraction of cars cause a disproportionate fraction of emissions of air pollutants,⁸ hence a rather small effort to improve inspection and maintenance of the highly sophisticated pollution control devices on cars would probably greatly reduce automobile emissions (Glazer et al., 1995). The fuel efficiency of new cars in the U.S. has been greatly improved at acceptable cost, under the pressure of fuel price increases and the mandate of corporate average fuel economy (CAFE) standards. Narrowly targeted restrictions on motor vehicles, such as bans in selected areas with high pedestrian potential, can control some of the worst pollution and noise impacts without substantially changing the role of motor vehicles in urban life.

5. Motor-vehicle accidents

Motor-vehicle accidents accounted for about 42,000 deaths and anywhere between 2.0 million and 5.7 million injuries in the United States in 1993.⁹ They are the leading cause of death for people aged 1 to 24.¹⁰ Motor-vehicle accidents are

⁷Adding the lower bounds of pollution and global warming costs just estimated yields \$0.008 + \$0.021 = \$0.029 per mile, and adding the upper bounds yields \$0.038 + \$0.031 = \$0.069 per mile. These two numbers are converted to an equivalent fuel tax by multiplying by average fuel economy of 21.7 miles per gallon.

⁸See Stedman and Bishop (1990), Lawson et al. (1990), Caivert et al. (1993).

⁹U.S. Bureau of the Census, tables 1011 and 1033. The lower injury figure is attributed to the National Safety Council, the higher to the Insurance Information Institute.

¹⁰U.S. Bureau of the Census (1995), table 127.

therefore a significant public-health problem, just as they are in western Europe where fatalities per vehicle-mile traveled are somewhat higher¹¹

Yet motor-vehicle accidents do not seem to have stimulated the same kind of public response as some less easily measured problems such as the health impacts of diet, exercise, or environmental pollutants. For example, certain suspected carcinogens, such as chrysotile (a form of asbestos) and the less-chlorinated forms of polychlorinated biphenyls (PCBs), are subject to extremely strict regulation despite lack of agreement within the scientific community on whether they pose any significant public-health risk (Stone, 1991, Abelson, 1991). Why is there public support for draconian measures to limit the use of unproven carcinogens, while practically no support for comparable measures to limit the use of motor vehicles?

As another indication of the puzzle, the per-mile accident costs shown in Table 1 are considerably larger than the admittedly uncertain estimates of environmental costs discussed earlier. The figure of \$0.110 per mile (\$0.068 per km) includes insurance overhead and a measure of willingness to pay for reduction in risk of death. The latter incorporates a valuation of \$4.5 million per statistical life, based on measured willingness to pay for small changes in occupational safety, it excludes any similar consideration for injuries, valuing them at just medical costs, so is probably a conservative estimate. [A moderately higher estimate of U.S. accident costs is obtained from a study of 1988 accidents by Miller (1993)]

It is apparent from the table that these accident costs, while substantial, are not so large as to overwhelm the other costs that people voluntarily bear when driving automobiles. For example, they are only 21 percent as large as the first four categories shown in the table, which exclude parking or motor-vehicle taxes. Therefore, we might expect that if drivers were faced more directly with these accident costs than they are now, they might take greater measures to reduce accidents, but these measures would not include drastic curtailment of automobile use. Recent marketing trends in the automobile industry confirm that customers are willing to put up substantial sums to improve safety, for example by paying for antilock brakes, air bags, and other safety features (McCarthy, 1990, Calfee and Winston, 1993, Mannering and Winston, 1995)

If this is so, what justification is there for any government intervention? There are at least three arguments. First, the widespread use of insurance reduces the individual's incentive to pay voluntarily for safety measures that would reduce accident costs. Second, because insurance rates bear only an indirect relationship to the amount of driving, the insurance system may be causing drivers to perceive what really is a variable social cost (accidents) as a fixed private cost (insurance). Finally, a considerable fraction of accident costs, perhaps half, are external to the individual driver, borne instead by pedestrians, bicyclists, occupants of other vehicles, the public-health system at large, and publicly financed police depart-

¹¹AAMA (1995), p. 94

ments and court systems (Vickrey, 1968, Newbery, 1988; Jansson, 1994). (Of these three categories, the interuser externality is a marginal externality cost not included in Table 1, the others are social costs included in the table but not in drivers' private cost calculations)

It is difficult to translate such considerations into optimal user charges, because accident externalities are addressed in complex ways through tort law, criminal law, and insurance regulation (Boyer and Dionne, 1987). Nevertheless, we can obtain some insight into the maximum potential behavioral impacts of such user charges. Suppose an extreme case, that *none* of the average accident costs in Table 1 are now perceived by users as variable costs, and that *all* of them are incorporated into a new mandatory insurance program paid for through a fuel-tax surcharge. This would be a more drastic version of "pay-at-the-pump" proposals for insurance reform currently being considered in the U.S., although it still would not internalize the interuser externality. At current rates of fuel consumption, such a policy would add \$2.47 per gallon (\$0.63 per liter) to gasoline prices. While this figure is higher than those discussed in connection with air pollution and global warming, it still does not differ greatly from fuel-price differentials between the United States and several European nations (U.S. Bureau of the Census, 1995, table 1400). A deterrent of this magnitude might make a noticeable difference in motor-vehicle use, but the European experience suggests that it would not place a permanent brake on its growth.

I conclude that even in the absence of other measures to reduce the danger of accidents, charging people the social cost of accidents would lead at most to only moderate changes in overall use of motor vehicles. But in fact, reducing overall automobile use is a very clumsy way to address the specific problem of motor vehicle accidents, just as it is to address air pollution. Experience shows that at costs far less than the value people place on automobile travel, technological or behavioral measures to reduce accident rates and their severity can be put in place. This is in fact exactly what is happening in the United States. Many road improvements have been made with traffic safety as an objective. Increasingly stringent safety regulation has added \$1000 or more to the price of a car to make it safer.¹² And in a reversal of traditional opposition to "social engineering," federal incentives have induced most states to raise the legal drinking age to 21 in order to reduce automobile accident rates among teenagers. Many states have also strengthened laws against driving while drunk. Apparently, such measures affecting roads, vehicles, and drivers are effective. The rate of traffic fatalities per

¹²Crandall et al. (1986, table 3–4, p. 37) estimate the cost of safety regulation (including bumper standards and related extra fuel consumption) at \$609 per car (1981 prices), for standards effective with 1984 model automobiles in the U.S. Inflating this by the consumer price index for all items (U.S. Bureau of the Census, 1993, table 756) brings the cost to \$940 per car in 1992 prices. Additional regulations have been put in place since 1984, notably passive seat belts and driver-side air bags.

vehicle-mile in the US has fallen by more than 50 percent in the last two decades¹³

Given the magnitude of the accident costs that remain, it seems highly likely that additional such measures are warranted. Further restrictions on drivers' use of alcohol, which accounts for a large proportion of accidents, seem especially promising. If safety is an income-elastic good, we can expect that the development of further safety measures will be a continuing process as economic growth proceeds.

6. Traffic congestion

Traffic congestion is one problem of urban transportation for which there is a solution with a strong consensus among transportation economists. That solution is congestion pricing of highways, which means imposing charges on moving traffic for the explicit purpose of managing congestion. It therefore entails charges that are high during peak periods, and much lower off-peak. Despite severe political drawbacks, congestion pricing is today among the tools seriously considered by transportation planners.

As a result, the traditional academic literature on congestion pricing has now been supplemented by extensive analyses of the technical, administrative, and political prospects for practical implementation (Hau, 1992, May, 1992, U.S. Federal Highway Administration, 1992a, National Research Council, 1994, Gomez-Ibanez and Small, 1994). In what follows, I attempt to synthesize these research findings into a few key conclusions.

6.1 *Conclusion 1: congestion pricing would promote good urban transportation*

This statement expresses the belief that the theory developed by Pigou (1920), Knight (1924), Boiteux (1949), Walters (1961), Vickrey (1969) and others does in fact apply to real highways, and that most of the predicted efficiency gains would occur even in a world with imperfect institutions for implementing it.

Urban mobility in many parts of the world is degraded by the enormous amounts of time unnecessarily wasted in traffic jams. For example, on the San Francisco–Oakland Bay Bridge, aggregate time spent in congestion delay each weekday is estimated to have grown from 4730 vehicle-hours in 1984 to 10 080 vehicle-hours in 1991 (Dittmar et al., 1994). The total amount of extra travel time and fuel consumption caused by congestion, both recurring and occasional, has been valued at an estimated \$35 billion for 50 large US urban areas in 1988 (Schrank et al., 1993, p. 46). The few simulation studies that have been

¹³U.S. Bureau of the Census (1995, table 1033)

undertaken, such as those by Keeler and Small (1977), Mohring (1979) and Cameron (1991), suggest that a large proportion of this extra consumption of time and fuel would be eliminated under optimal pricing

Feasibility studies and actual experience with congestion pricing, as well as with closely related policies such as toll rings in three Norwegian cities, now provide ample evidence that at least some forms of congestion pricing are technically and administratively feasible. This evidence is discussed further below. Therefore congestion pricing represents more than just a theoretical possibility.

6.2 Conclusion 2 congestion pricing is the only policy that will make a noticeable difference in peak congestion levels in the world's most congested cities

Numerous policy initiatives designed to reduce traffic congestion, ranging from mass-transit subsidies to land-use restrictions, have failed to do so (Meyer and Gomez-Ibanez, 1981, Giuliano and Small, 1995). Some of these policies may create real and substantial benefits, but they can do little to reduce the most severe congestion (Downs, 1992). One reason is the existence of *latent demand*: people who are currently deterred from driving at congested times and places by the congestion itself. In many locations, there is so much latent demand for car travel at peak periods that any amount of capacity that can feasibly be built, or that can be released by enticing some drivers off the road, will quickly become filled by people who now opt for some alternative. This is a well-documented empirical phenomenon known as the “fundamental law of traffic congestion” (Small, 1992, pp. 112–114), and is explained by a simple equilibrium model expounded, for example, by Downs (1962), Smeed (1968), Thomson (1977); Holden (1989), Arnott and Small (1994).

If, as suggested earlier, mass transit is provided with increasing returns to scale, then latent demand can have an even more perverse effect. In areas with pervasive mass transit, an equilibrium is established between the full cost of travel by auto and by transit. Expanding road capacity then draws users away from mass transit, driving up its average cost, until a new equilibrium is established in which higher average costs prevail on both modes: on transit because it is less used, and on highways because they are even more congested than before. In such a situation, expanding capacity makes congestion worse! Evidence for such equilibria is provided by Mogridge (1986), and the phenomenon is formally modeled by Downs (1962); Mogridge et al. (1987) and Holden (1989).

In such a situation, implementing congestion pricing could produce a modal shift toward mass transit that would be accentuated by the resulting decrease in the average full cost of travel by transit. It is possible that a quite dramatic reduction in the proportion of travel by automobile might occur in some dense city centers well served by public transit. An empirically based model of such a case is provided by Viton (1983).

6.3. Conclusion 3 congestion pricing could aid the urban economy

Increasingly, the urban economy is being drained by the waste inherent in traffic congestion and by the many measures being undertaken to ameliorate it, from employer carpooling mandates to billion-dollar expressway widenings. In a typical large metropolitan area, full-scale congestion pricing would free up hundreds of millions of dollars of real resources annually for improvements in urban life.

Those who fear that congestion pricing would harm cities economically tend to forget that every dollar extracted from urban travelers through tolls is a dollar that can be used to add urban services, to pay for needed transportation improvements, or to reduce other taxes paid by urban residents and businesses. So long as the resources represented by the toll payments remain within the urban economy, the benefits from eliminating congestion will be a pure economic gain to the region.

Of course, this qualification requires that the revenues be used in ways that benefit urban residents and businesses. The biggest danger to success of congestion pricing may be the possibility of "capture" of the revenues by special-interest groups, or by planners with good intentions but poor respect for cost-benefit analysis. Revenues could be wasted on transit systems that are not used, or on highway capacity expansions that are no longer necessary. There is a real challenge here for transportation professionals: we need to predict the new demand patterns that would emerge from congestion pricing, and to do so accurately enough to spot unwise expenditure plans before it is too late.

Congestion pricing could also have important effects on land-use and commuting patterns. For example, it would encourage shorter work trips both by reducing the cross-hauling inherent in present commuting patterns (Giuliano and Small, 1993) and, in the longer run, by promoting jobs-housing balance in land-use patterns. A full analysis of land-use implications, taking into account dispersed and polycentric employment patterns, remains to be accomplished (Deakin, 1994).

6.4. Conclusion 4 congestion pricing is a respectable policy alternative.

The concept of congestion pricing, having spent its first 70 years in ivory tower oblivion, suddenly became all the rage among transportation and public policy professionals in the early 1990s. Highway officials, business groups, transportation engineers, air quality regulators, environmental groups, and even many local bureaucrats began to endorse "market-based" approaches to congestion and air pollution after decades of unsuccessful use of other policy instruments.

While political realities have intervened to cool the ardor of advocates, there has been some headway even among politicians. The cities of Bergen and Trondheim in Norway have area pricing schemes that apply only during certain hours. Plans that involve congestion pricing have been endorsed at various times by majority political groups in greater London, the Netherlands, Stockholm, and Cambridge (England) (Gomez-Ibanez and Small, 1994). I hasten to add that some of the key

political figures are no longer in power, and earlier plans in these regions have been modified. In the United States, the private sector is providing the first U.S. congestion pricing experiment: a new four-lane road in the median of the existing Riverside Freeway in southern California, financed by revenues from a toll structure with sharp variations over the peak period. This road opened to traffic in December, 1995.

The lead taken by the private sector in California parallels that taken by SANEF, a publicly owned corporation which operates 1004 kilometers of French toll roads. In April 1992, SANEF inaugurated a limited congestion-pricing experiment to flatten the Sunday evening traffic peak consisting mainly of weekend travelers returning to Paris from the north of France (Gomez-Ibanez and Small, 1994). This experiment is revenue neutral — the price is raised during the peak and lowered during the shoulders of the peak, relative to the normal toll. This pricing structure enabled SANEF to introduce the scheme with virtually no redistributive effects (except among different users of the toll road), a feature which greatly facilitated its political feasibility.

6.5 Conclusion 5: widespread adoption of congestion pricing is not likely in the foreseeable future

In the United States, especially, the problem of political feasibility is a fundamental one. Put simply, the average person on the street thinks that congestion pricing is a bad idea. The political liabilities are severe and present overwhelming odds against rapid adoption (Giuliano, 1992; Rom, 1994).

Perhaps through the demonstration process, people will be eased into the idea gently and will discover that it is not as bad as they feared. There are a number of avenues for introducing congestion pricing quite naturally: as a financing structure for new toll roads, as a modification of the pricing structure for existing toll bridges, as a special measure for a particular “problem area” such as an airport. Each of these offers the opportunity to demonstrate how pricing can work in practice, although each also offers the danger of a failed experiment receiving adverse publicity. Grieco and Jones (1994) suggest that even when not adopted, the serious consideration given road pricing in various European locations has allowed the concept to migrate to other locations.

Another natural experiment is allow spare capacity on high-occupancy vehicle lanes to be used, for a fee, by low-occupancy vehicles. This effectively subjects the low-occupancy vehicles to congestion pricing because only during peak hours would they wish to pay extra for the special lane, which in this case is called a “high occupancy toll” (HOT) lane. Fielding and Klein (1993) have proposed that this kind of demonstration could migrate to adjacent lanes, as people come to accept and value the option for high-quality service. Indeed, a (subsequently rejected) proposal to gradually toll the entire Seattle freeway system in just this manner passed the Washington State Transportation Commission. In Fall 1996, a

HOT lane began operation on Interstate 15, north of San Diego (Duve, 1994, Oropeza et al., 1996), there are also the several studies being funded under a partially defunct U.S. congestion pricing demonstration program

Europeans seem somewhat less resistant than citizens of the United States to the kind of state intervention that road pricing represents, a conclusion supported by the agreements already reached in Scandinavia. Polling data from Norway and England suggest that people may support pricing strategies when used to finance desired public expenditures (Jones, 1991, Tretvik, 1992).

6.6 Conclusion 6: congestion is an inherently self-limiting phenomenon

Usually when congestion gets too bad, people stop doing the things that cause it. We are therefore not doomed, even in the absence of sound policies, to ever-worsening congestion and hopeless urban gridlock. This does not mean there is no problem, it just means that there is an inefficient equilibrium rather than an unstable positive feedback loop. The self-limiting characteristic of congestion is in contrast to several other urban problems such as racial intolerance and short-run fiscal health (Bradbury et al., 1980).

One example of this self-limiting characteristic is the tendency of people to relocate in order to avoid congestion. This probably explains the finding that even though congestion seems to have increased on specific facilities (Schrank et al., 1993, Meyer, 1994), average commuting time has not increased (Gordon et al., 1991, Pisarski, 1992). Employment and housing have suburbanized, enabling many commuters to keep a step ahead of congestion as it follows them outward.

Another ameliorating factor is that automobile ownership and use appear to be approaching saturation. Lave (1992) shows that growth in registered automobiles per driving-age adult has nearly leveled off in the U.S., with Europe not too far behind. Reasons include two demographic facts: people who grew up before driving was virtually a universal skill are now a small minority, and women's labor-force participation has now reached approximately the same level as men's. Added to this is a secular growth in incomes that has finally permitted virtually every driver to own a car.

It is possible that these forces will take hold before congestion pricing catches on and will undermine its support. If so, urban areas may remain stuck in an inefficient transportation system, but one that people deem tolerable.

7. Conclusion

Quantitative economics is not the only vantage point from which to examine transportation policy, but it can at least focus attention on a range of sensible options. I have argued that doing so for the case of urban transportation in the United States provides some strong guidance as where *not* to look for solutions:

namely, widespread reduction of motor vehicle use. Far more defensible are targeted policies that use either pricing or regulatory measures to bring about technological or behavioral changes that reduce air emissions, enhance safety, and reduce congestion. Financial problems of infrastructure management and transit subsidies are amenable to rationalization that would greatly reduce cost.

In the cases of air pollution and safety, measures already undertaken seem to be having the desired effects. This is not to argue that the precise measures chosen are necessarily the most efficient ones, or that the correct tradeoff between economic costs and safety improvements has been achieved. However, the success of such measures reinforces the main argument made here: that the fundamental approach most beneficial to people's welfare is one that induces micro changes in behavior and technology, aimed directly at the problem, and not one which aims to effect broad changes in mobility patterns.

None of this is meant to imply that drastic changes in the amount of motor-vehicle use should not occur in selected locations. Congestion pricing would certainly curtail, though not eliminate, peak-period use in currently congested areas. It is entirely possible that bans or restrictions on motor vehicles in selected neighborhoods are justified in order to improve the residential or pedestrian environment. Furthermore, a thorough-going reform of pricing and investment policies toward urban transportation in urban areas might produce drastic increases in use of public transit in selected commuter markets, especially in dense central business districts. Thus efficient policies would produce urban areas with quite altered features, but those areas would continue to depend heavily on motor vehicles.

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