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1. Introduction

Cities exist because they enable people to take advantage of economies of agglomeration, where spatial proximity facilitates productivity-enhancing cooperation. Transportation defines proximity and therefore determines how economies of agglomeration are realized. The functioning of the transportation sector, therefore, is central to the functioning of the urban economy.

In simplified urban spatial models, transportation is usually assumed to be a linear function of distance. In real cities, of course, it is more complex. Transportation facilities are provided in the form of networks, and the amenities and capacity they provide are subject to complex choices and often to economies of scale.

Urban transportation therefore involves important nonlinearities in two ways: in its purpose and in its form of provision. Under such conditions, there is ample room for market failures and it is not surprising that public intervention plays a heavy role. But public policy failures are common too, and many of the issues currently at the forefront of urban transportation policy involve how to make public intervention more beneficial. In particular, to what extent can market mechanisms be relied upon, either unregulated or as models for public activities?

In this chapter, we examine the role that economic analysis plays in analyzing such questions. We focus heavily on highway transportation in private vehicles, just as do actual travelers. Many people have argued that travel in private motor vehicles is overemphasized due to a neglect of its full social costs. We examine in detail three such costs: congestion (and the related investments in infrastructure capacity), air pollution, and accidents. Next, we examine public transit as an alternative to the automobile, taking up the question of the effects and merits of subsidies. Throughout, we focus on analytic methods and findings that bear on current policy issues, as well as the factual basis for policy analysis.

2. Highway Infrastructure Costs and Congestion

In modern urban areas, the provision of infrastructure for roads and streets is dominated by the need to provide ample capacity to handle peak period flows. Investment decisions thus involve a tradeoff between infrastructure and congestion costs, and so it makes sense to discuss infrastructure expansion and congestion as a single policy issue.

While our primary focus is on congestion relief as the motivation for infrastructure enhancement, it is important to note that there are other motives as well. Capacity investments may improve safety or raise speeds even when the road is uncongested, for example, by providing intersection bypasses or by making a road straighter. Larsen (1993) shows that this may considerably alter the usual analysis, attributed to Mohring and Harwitz (1962), of the relationship between optimal investment and the value of congestion relief.

2.1 Congestion Severity and Growth

Road congestion is widely perceived to be one of the most pressing problems of urban transportation [Small et al. (1989), Newbery (1990), Downs (1992), National Research Council (1994)]. Calculations suggest that congestion is responsible for billions of dollars per year in many of the world's largest metropolitan areas in lost time. [Lindley (1987, 1989), Hanks and

Lomax (1991), Quinet (1994)]. For example, statistics on the ratios of daily vehicle flows to highway capacity suggest that Chicago was the fifth most congested metropolitan area in the U.S. in 1990. Its population of 7.5 million suffered annual congestion delays of 155 million vehicle-hours. Assuming an average value of time of $12.50 per vehicle-hour, this works out to $1.94 billion per year in time costs; adding $350 million for extra fuel consumption yields $2.3 billion, or $570 for each registered vehicle, in annual costs [Schrank et al. (1993), tables 5, 11, 16, 17]. For the U.S. as a whole, Lindley (1989) estimates congestion costs at $16 billion annually.

Whether congestion is worsening depends upon how it is measured. On any given set of roads, there is abundant evidence that congestion has become worse in most large cities. For example, of the 50 large U.S. metropolitan areas studied by Schrank et al. (1993, table 6), all but three showed an increase between 1982 and 1990 in a "congestion index" that reflects ratios of daily volume to capacity on selected road segments. Between 1986 and 1990 the average area suffered an estimated 18 percent increase in vehicle-hours of delay (their table 14). Anecdotal evidence of increases in congestion abound.[1] London, famous for its all-day traffic congestion, experienced steady declines in average speeds from 1968 through 1990, although this appears to have been reversed by the recession of the early 1990s ['Traffic Speeds...' (1995)].

Speeds faced by the average person, however, have not necessarily declined. U.S. data suggest that average trip times and speeds have changed little since the mid 1970s [Gordon et al. (1991), Gordon and Richardson (1994)]. Journey-to-work statistics from the U.S. Census show, for example, that the mean commuting travel time in the largest 15 metropolitan areas

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[1]See for example Meyer (1994), ECMT (1995, pp. 72-76), Levy (1994), and Daniere (1995).

increased only slightly, from 26.0 to 26.6, minutes between 1980 and 1990.[2] This finding need not conflict with the findings of worsening traffic on specific roads:

> ... not only is there no contradiction but the two phenomena are causally related. Rational commuters will, sooner or later, seek to escape congestion by changing the location of their homes and/or their jobs.... The process is facilitated by the decentralizing location decisions of firms seeking to move closer to suburban labor pools. [Gordon et al. (1991, p. 419)]

In other words, people have been escaping worsening congestion by moving homes and jobs to the suburbs. Whether this is efficient, as argued by Gordon and Richardson in numerous articles, is quite another question; given that traffic congestion is an unpriced externality, congestion-induced dispersal is a distortion that may or may not be desirable as a second-best adaptation. In either case, the distortion should be counted as one of the costs of congestion [Downs (1992, p. 2)].

Another measure of urban traffic congestion is the ratio of marginal to average time cost for a motorist. This ratio has been estimated at 2.2 during the peak hour on an arterial highway in Edmonton, Canada [Shah (1990), p. 15], at 1.9 for an average of 20 Indonesian urban roads, evidently for all-day conditions [Hau (1994), table 2], and at 2.3 for a sample morning peak trip in the Minneapolis area [Mohring and Anderson (1994), pp. 37-38].

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[2]Rossetti and Eversole (1993), tables 2-1 and 4-13. These figures exclude Boston because of missing data for 1980 employment, which is used to weight the averages for each metropolitan area; Boston's mean travel time increased from 23.4 to 24.2 minutes. The average masks substantial differences: in the largest area (New York) the mean commute time *decreased* by 7.7%, whereas in the second largest (Los Angeles) it *increased* by 11.9%; it also increased in each of the other 13 areas, by an average of 5.4 percent. Figures are for the Consolidated Metropolitan Statistical Area if there is one. For recent comparisons, these census data may be more reliable than those from the National Personal Transportation Survey (NPTS), since the survey methodology for the latter changed between the latest two surveys (1983 and 1990), possibly causing the latter to be overweighted with newer cars [Lave (1995)].

It is not difficult to find underlying sources of rising congestion. Statistics compiled by the International Road Federation (1980, 1990) show that automobile ownership and use is growing considerably faster than the roads system in most nations. Selected statistics are shown in Table 1. Data for urban areas are less readily available, but the trends seem to be the same. In the United States, for example, urban automobile use grew 65 percent from 1980 to 1993 while urban highway mileage grew only 29 percent.[3]

Car ownership and use are growing very rapidly in Western Europe, and the gap between European and U.S. ownership rates is narrowing. Selected comparisons between the United States and the 17 member nations of the European Conference of Ministers of Transport (ECMT) are shown in Table 2. Between 1970 and 1990, per-capita ownership grew by 32 percent in the United States, compared to 111 percent in Europe.

The value of the highway stock does not appear to have increased with motor vehicle use in recent years, at least in the United States and Europe. In the United States, the depreciated value of cumulative road investment declined for more than a decade following its remarkable buildup during the 1950s and 1960s.[4] In Europe, real investment on all land transportation has fallen by some 10 percent since 1975, to less than one percent of gross domestic product [(Banister (1993), p. 348].

Lave (1992) has shown that United States car ownership trends are leveling off as they approach one car per driving-age adult. He also argues that growth in car ownership has been accelerated by a number of trends that have played out their logical course: increased labor force

[3] U.S. Census Bureau (1995), table 1012, and AAMA (1995), p. 65.

[4]See Winston and Bosworth (1992), fig. 8-2, and Gramlich (1994), fig. 3.

participation by women, the spread of driving ability into upper age groups, and rapid growth of young and middle-aged population groups due to the "baby boom" between 1945 and 1964. Indeed, the growth of motor vehicles in use came to a temporary halt during the recession year of 1992, and in per capita terms it has been flat since 1990 at a value of 0.72 [U.S. Census Bureau (1995), tables 14, 1008]. However, congestion also depends on local population growth and on the amount that each vehicle is driven. Trends in usage per vehicle are unclear: in the United States, the reported annual distance traveled per vehicle rose from 1950 to 1970, then declined to 1980, then rose again by 23 percent to a peak value of 18,700 km in 1993 [AAMA (1995), p. 66]. In other nations, there is more room for continued growth in use per car since car ownership levels are far below the natural saturation level of one per potential driver.

2.2 Financing New Infrastructure

As motor vehicle traffic has grown, many nations have found that traditional methods of highway finance cannot support needed road building programs. Much of the growth in traffic has occurred in densely urbanized areas where road expansion is very expensive. Furthermore, past expansion sometimes relied on taxes whose bases are not growing commensurately with traffic.

In Europe, for example, fuel tax revenues have more than covered highway expenditures in most nations [Pucher (1995a)] but physical constraints on highways are important in many congested cities. In the United States, a major problem has been the historic tie between highway investment funds and fuel tax revenues. Table 3 shows average fuel tax rates in nominal and real terms. Since 1960, the real tax rate per vehicle-mile has been cut in half as state legislatures have raised nominal tax rates by less than inflation and as the fleet average fuel efficiency has grown.

One response has been to finance new roads at the time of land development, in the form of land use exactions. The rationale is that land development creates new traffic sources, so the infrastructure to handle these sources can be legitimately charged to the developer. Furthermore, recent evidence suggests that many types of development do not produce enough local revenue to cover the public service costs resulting from the development [Altshuler and Gómez-Ibáñez (1993), ch. 6]. Altshuler and Gómez-Ibáñez find that these land use exactions are seriously flawed on grounds of equity and efficiency, especially compared to user charges; but that such exactions are preferable to stringent growth controls, which are the only politically feasible alternatives in many cases.

In cities with intense peak-period travel demand and congestion, expanding road capacity may not reduce peak congestion but rather simply induce more people to travel during the peak. These people constitute a "latent demand" for peak travel that is currently deterred only by the extent of congestion. Capacity expansion still creates benefits in such cases, inasmuch as more people can now exercise their preference for peak-period motor-vehicle travel, but it is unlikely to eliminate peak congestion. Downs (1962) describes this phenomenon as a "fundamental law" of traffic congestion in large cities: expressway traffic will grow to the point that peak expressway travel times are comparable to those on competing arterial streets or transit routes. If the competition is with public transit service instead of arterial streets, things are even more perverse: because transit service is provided under increasing returns to scale when people's waiting times are taken into account [Mohring (1972)], expanding highway capacity may degrade the service that the transit operator can offer economically by attracting riders from transit. This phenomenon, sometimes called the "Downs-Thomson paradox," is described by Downs (1962) and Holden (1989); Thomson (1977) and Mogridge et al. (1987) provide suggestive empirical evidence from London.

Another response to the inability to finance infrastructure expansion has been to impose measures to utilize existing infrastructure more efficiently. Some of these measures involve controlling demand, which is treated in the next subsection. Others involve physical or operational changes that effectively increase capacity. Such measures, known as transportation systems management (TSM), are logically thought of as part of the investment design problem, and considerable attention has been devoted to them ever since Kain (1970) eloquently portrayed them as a low-cost alternative to road widening. Some TSM measures, such as arterial signal timing and ramp metering on expressway entrances, are now routine in many areas and quite effective in modestly augmenting capacity.

One TSM measure now emphasized in many pollution control plans in the United States is reserving lanes for high occupancy vehicles (HOVs) such as buses, vans, and carpools. HOV lanes are most commonly viewed as demand management policies aimed at enticing more people to form carpools. An equally important function, however, may be to reduce aggregate travel time by speeding up high-occupancy vehicles at the expense of low-occupancy vehicles. In a queuing context, this amounts to imposing a more efficient queue discipline. For example, suppose it takes two seconds for each vehicle to pass through a bottleneck; if a four-occupant carpool is moved ahead of ten single-occupant cars in the queue, 80 passenger-seconds of delay are saved by the carpool at a cost of 20 passenger-seconds of additional delay by the solo drivers.

Mohring (1979) and Small (1983) consider both functions of HOV lanes in the cases of urban arterials and expressways, respectively. They find that HOV lanes produce substantial benefits, approximately half those possible from fully optimal pricing. Their calculations assume that no capacity is lost in the process of separating the traffic streams, and that any desired fraction of capacity can be allocated to HOVs. Where indivisibilities make these assumptions untenable, benefits are lower and may become negative; nevertheless, Small (1983, p. 60) still finds positive benefits with as much as 29 percent of an expressway's capacity wasted through indivisibilities.

Fuhs (1993) reviews the extensive experience with HOV lanes in the U.S. and Canada. Giuliano et al. (1990) estimate the modal diversion resulting from a new HOV lane in Orange County, California, finding that about 4 percent of peak-period workers using the route were induced to join carpools. Kain et al. (1992) provide comprehensive case studies of many HOV lanes and busways in North America; they find construction costs per daily passenger round trip served to vary from \$3,900 to \$10,400 (1988 prices) for new facilities and from \$20 to \$410 for lane additions to existing facilities, in comparison to \$38,800 for an average of four light rail systems (p. ii). They also report favorably on early experience with a guided busway, opened in 1986 in Adelaide, Australia, whose vehicles can also travel on regular city streets.

TSM measures may include other direct controls on vehicle movements, from controlled left turn lanes to one-way streets, and from peak-hour limitations on curbside parking to partial or complete bans on vehicles in designated parts of cities. The latter is used successfully in many European cities, especially in historic areas with narrow streets.

2.3 Demand-Side Measures for Congestion Relief

Increasing the supply of highway infrastructure is, of course, only one way of dealing with supply-demand imbalance. Another way is to manipulate demand. Terminology is not uniform, but we divide such demand-side measures into four categories: land use controls, public transit enhancement, a diffuse category called "transportation demand management," and pricing.

Land use controls. As noted earlier, the demand for transportation is derived from the spatial separation of land uses. Therefore, it is natural to look to land use policies as a starting point for influencing travel demand.

Many urban planners have linked congestion to local imbalances between employment and housing, arguing that high-density employment centers often lack nearby housing suitable for their workers [Cervero (1989a, 1989b), Nowlan and Stewart (1991)]. For this reason, many cities tried to achieve a closer balance by restricting suburban sprawl, by channeling growth into outlying satellite towns, or by dispersing job growth to locations where residential sprawl has already occurred.

In the United States, however, Giuliano (1991) demonstrates that most municipalities are in fact balanced, and that the imbalances that do occur tend to be eliminated over time by market forces. Indeed, Small and Song (1992) show that in the Los Angeles region, employment and housing are sufficiently interspersed so that the average commute in 1980 could be reduced to one-third its actual value without changing land-use patterns, just by reallocating workers to different houses. Giuliano and Small (1993) go on to show that this result holds up even if only workers within the same industry can be reallocated, suggesting that mismatches of incomes with housing types is probably not a primary cause of long commutes. Thus, factors other than availability of housing are causing people to live at some distance from their jobs. Those factors probably include public services, amenities, racial segregation, frequent job searches [Crampton (1988), Rouwendal and Rietveld (1994)], and the complexities of job and housing choices by two-worker households [Kim (1995)].

Comparable calculations for Tokyo reveal a pattern of residential choices much more constrained by the available locations of housing [Merriman et al. (1995)]. Tokyo is a residentially dispersed metropolitan area with strong job concentrations in the central areas. This land-use pattern and the high public transit use produce a much longer average commuting time than in any U.S. city. Furthermore, two-worker families are less common in Japan than in most developed western nations. In such circumstances the journey to work is more likely to be the dominant consideration in the choice of housing location.

Newman and Kenworthy (1988, 1989) use data from 32 large metropolitan areas in developed countries to argue that the major determinant of automobile usage is the density of development. They show that metropolitan areas with residential densities above 30 to 40 persons per hectare, such as those in Western Europe and Japan, tend to have much lower levels of automobile usage and rely more heavily on public transportation than their lower density counterparts in Canada, Australia, and the United States. However, they do not control for the effects of other variables, such as income levels, that might influence the mix of auto and transit usage [Gordon and Richardson (1989), Gómez-Ibáñez (1989)].

Furthermore, it is not clear that international differences in urban densities are primarily policy-driven. High urban densities in some cities of Europe and East Asia may be due in part to a scarcity of habitable land relative to total population. But the basic reason why European cities are denser is that they experienced their greatest population growth before the automobile era was fully upon them. More recent developments on the peripheries of European cities have densities and patterns of transport use quite similar to those in the United States.

Even if cross-national differences in urban development patterns are the result of past policies favoring automobiles, those patterns are extremely difficult to reverse. Downs (1992) systematically examines the prospects for using land-use regulation to reduce transportation demand in U.S. metropolitan areas. Downs defines a prototype city, complete with suburban subcenters, and applies empirical travel propensities to model various land-use changes. He finds only a tiny effect on travel patterns from any regional land use policies that are even remotely politically feasible. In part this is due to the fragmented governmental structure in U.S. metropolitan areas and the ferocity with which local governments protect their powers of land use planning.

Finally, most advocates of using land-use policies to influence transportation choices ignore the information land-use markets are providing about economic efficiency. Urban job concentrations have deep roots in agglomeration economies, which in turn underlie the economic functioning of large cities. Although there may well be market failures in land development that prevent optimal land use, heavy-handed regulation that subverts land markets could exact a high cost. There seems to be little empirical research on how business efficiency is affected by policies aimed at limiting the spatial concentration of industry. Given the interest in such policies, their widespread use outside of North America, and their potentially far-reaching effects, such research could have a high payoff.

Public transit. Another widespread approach to alleviating congestion has been to promote public transportation in the hopes of enticing people not to drive cars during peak periods. The prospects of public transit are discussed in more detail later but, in brief, the experience of using transit improvements to reduce driving is disappointing. Furthermore, there is evidence that most of the drivers diverted to public transit are replaced by drivers who otherwise would travel at other times, take other routes or modes, or not travel at all [Small (1992a), pp. 112-116]. This is another example of the "fundamental law" of traffic congestion discussed above: in large congested cities a very large fraction of potential peak travelers must be enticed into transit before the latent demand for peak highway use is absorbed.

Nor does improving urban mass transit appear to be a very promising way to change land-use patterns, especially where it carries only a small proportion of trips. Small (1986) provides some useful numerical examples showing that given the current built environment, feasible changes in transportation policy can alter locational decisions too little to make much difference in urban form.

Transportation demand management (TDM). TDM is an ill-defined term, usually applied to policies that attempt to directly influence travel behavior, especially for work trips. Pricing measures are sometimes included, but we separate them here because they use a quite different means of influencing behavior. TDM measures are often categorized under the somewhat broader rubric of "transportation control measures" or "congestion management."

One popular approach has been to promulgate regulations that force or encourage employees to restrain peak-period highway use by their workers; employers might do so by offering preferential parking for carpools, by adopting flexible work hours, or by permitting employees to work at home or at special centers equipped with special-purpose telecommunications. Other measures involve parking limitations, ride-sharing information services, or improvements for bicyclists and pedestrians.

OECD (1994) and Apogee Research (1994) review the experience with TDM measures and conclude that most have disappointingly small results and that some are very costly to employers and users. Of fifteen measures reviewed by Apogee (1994, pp. 23-29), for example, none of the non-pricing measures are judged to have the potential to reduce regional vehicle travel by as much as 1.5 percent in a typical U.S. metropolitan area. Furthermore, very few of them achieve trip reductions at a financial cost of less than $1.70 per vehicle round trip avoided (which is the estimated net cost of a policy of requiring that employees pay for parking pricing); some examples are $10.30 per round trip avoided for other employer-based measures, and $10.60 for bicycle and pedestrian facilities. One exception is ridesharing information and promotion, which achieves only small reductions in vehicle trips but also incurs only $0.60 in administrative expenses per round trip avoided.

Formal statistical investigations of TDM measures are scarce. Giuliano and Wachs (1995) estimate the effects of various incentives offered by 243 large Southern California employers in response to Regulation XV of the local air quality control district, in effect from 1988 to 1995, which required plans (but not results) on the part of such employers. Their dependent variable is the target variable of the regulation: average vehicle occupancy for employee work trips during peak periods. Only three incentives were found to have a statistically significant impact during the first two years: information and marketing, subsidies for alternative modes, and parking incentives for carpools. ("Parking incentives" consist mainly of preferential parking for carpools, but the category also includes rarely used pricing incentives, making it hard to know which policy is producing the positive results.)

Brownstone and Golob (1992) examine the Los Angeles experience through a disaggregate travel demand model estimated on a sample of 2,189 commuters. They find that two categories of ridesharing incentives have substantial and statistically significant effects on choice of carpool mode: preferential parking at work and the availability of HOV lanes. They are unable to detect effects from the other categories investigated including financial subsidies (which are scarce and may have been poorly measured) and employer guarantees of rides home for people who miss their carpool or who must return home early for emergencies.

Pricing measures. Most of the policies discussed above elicit only small changes in behavior because they change the relative advantages to travelers of different modes, times, or routes only slightly. Even HOV lanes, potentially a big time saver, do not perform as well as hoped because of the additional time and loss in flexibility involved in sharing rides, especially where trips are dispersed and work schedules are flexible. The policies also do nothing to reduce the attractiveness of peak-hour vehicle use for categories of trips not targeted directly, and thus tend to be undermined by latent demand.

Pricing measures, by contrast, can significantly deter trips of all types, while permitting flexible travel patterns. They encourage people to use ridesharing or mass transit when feasible, but allow them to switch to the car at other times.

There is considerable evidence that pricing policies can significantly change trip behavior [Giuliano and Small (1995)]. The type studied most is pricing for parking. Shoup (1994) reports that parking is free for 99 percent of all auto trips in the United States. His research on seven case studies from Los Angeles, Washington (D.C.), and Ottawa demonstrates that charging realistic market rates for parking in large cities can increase the proportion of commuters who drive alone by an average of 25 percent. Shoup has advocated a relatively unintrusive method of charging for employee parking known as "cashing out free parking." Under Shoup's proposal, employers who offer free parking are required to offer an equivalent cash bonus as an alternative. A limited form of cashing out was legislated in California in 1992. The concept is severely inhibited by U.S. tax laws, however, since they exempt free parking, but not cash subsidies, from employees' taxable income.

One disadvantage of using parking charges to reduce congestion is that they do not deter through trips, which may in fact increase to fill the street capacity vacated by former free parkers. Of course, there is a market argument for pricing parking independent of its effect on congestion (as a means of optimizing the use of resources to provide parking spaces). However, the presence of congestion and tax distortions makes the practice of including free parking as a standard fringe benefit of employment less socially efficient or desirable.

A more direct approach to the congestion problem is to price roads at marginal congestion cost, a policy known as congestion pricing. Vickrey's (1955) eloquent advocacy stimulated academic, but little practical, interest in congestion pricing for many decades. Practical interest has revived somewhat recently, however, due to a combination of government needs for additional revenue sources, failures of other measures to reduce congestion, and new technology that makes it feasible to price roads without toll booths [Small et al. (1989), ch. 5]. National Research Council (1994) provides a thorough, policy-oriented review. Key theoretical treatments include Walters (1961), Vickrey (1969), and Arnott et al. (1993).

Empirical evidence confirms that congestion pricing can substantially reduce congestion if the charges are high and well-targeted. The most dramatic example is Singapore, where from 1975 through 1994 a peak charge for entering the central area was assessed, first during the morning peak only and then during both morning and afternoon peaks. (Beginning in 1995 the charge was extended to all day on weekdays.) The entry charge varied roughly from US$1.50 to US$2.50 per day over those years, and the traffic into the central area was reduced immediately by 47 percent [Gómez-Ibáñez and Small (1994), ch. 3].

Low charges or charges that vary little by time-of-day have much less effect. Examples include three Norwegian cities which recently established toll rings around their central areas. The charges (roughly $0.72 to $1.60 per round trip) are small relative to incomes and vary little by time of day. Effects on traffic have been correspondingly small, probably less than 5 percent. The most interesting effects are in one of the cities (Trondheim) where the charge is lifted at 5 p.m., causing some travellers to delay their trips and some retailers to extend their shop hours [Gómez-Ibáñez and Small (1994), ch. 4].

Simulation models also suggest that congestion pricing would bring about significant reductions in congestion [Keeler and Small (1977), Harvey (1994), Mohring and Anderson (1994)]. Prices would of course vary widely; Harvey (1994, tables 3-4), for example, estimates average peak period fees of $0.06/km and $0.09/km for the San Francisco and Los Angeles metropolitan areas, respectively. Harvey's fees are not necessarily optimal but were chosen to reduce congestion to a specified level; they imply roughly $2 and $3 per daily round trip for a typical worker traveling during the peak in both directions. Harvey also estimates that a $3.00 per day employee parking fee would have a somewhat smaller effect on overall vehicle travel.

The politics of congestion pricing are not very favorable [Altshuler et al. (1979), Gómez-Ibáñez (1992), Giuliano (1992), Rom (1994)]. In many cases modest efficiency gains, which are difficult to guarantee in advance, are accompanied by extremely large transfers, which are all too predictable and visible. So perhaps it is understandable that the more grandiose plans for congestion pricing once advanced in Hong Kong, London, the Netherlands, and Cambridge, England, have been abandoned for now. It seems likely that experience in the near future will be limited to small demonstrations or special cases where time-varying prices can reinforce policies adopted for other purposes. Two examples are discussed in the next subsection: one where time-varying tolls are needed to finance new infrastructure, and another where a revenue-neutral change to a time-varying toll structure can solve a well-defined peaking problem on an existing toll road. A third possibility is a concept known as high occupancy toll lanes, in which unused capacity in a HOV lane is released for single-occupant cars for a fee, giving them in effect a time-varying toll since only during the peak period would they need to take the tolled lane at all. The first such facility opened in Riverside, California in 1995 and a proposal to convert existing HOV lanes to high occupancy toll lanes is under active consideration for Interstate Route 15 north of San Diego [Duve (1994)].

One of the keys to political viability of any road pricing scheme appears to be a clearly understood link between toll revenues and expenditures on things that citizens want. The Norwegian toll rings were designed to finance an explicit set of infrastructure projects. Similarly, a planned toll ring for Stockholm is part of a bargaining package involving new highways and rail improvements [Gómez-Ibáñez and Small (1994), ch. 4]. Jones (1991) finds that public opinion in London is much more favorable toward road pricing if it is presented as part of a package, especially one including improvements to public transportation. Many commentators in the United States believe that some or all of the revenues from road pricing would need to be offset by tax decreases for the concept to be viable. Small (1992b) employs this principle as part of an attempt to describe a congestion pricing package that would be Pareto-improving to broad classes of people, in the sense that the average person in each identifiable income class or interest group would be made better off.

2.4 *Private Toll Roads*

Our review of both supply-side and demand-side measures to alleviate congestion is discouraging: most policies seem either ineffective or politically unpopular. It is perhaps natural, then, that policy makers have increasingly turned to an old institutional arrangement: private highways. This method of providing highways simultaneously addresses supply- and demand-side approaches because a private firm builds the highway and chooses, within limits, the pricing structure. Gómez-Ibáñez and Meyer (1993) review the concept and recent experience in Europe, the United States, and several developing nations.

Most developed nations have some toll roads, mainly on intercity rather than urban routes. A number of these roads — especially in France, Spain, and Italy — are operated by private companies. Developing nations and Eastern European nations are also turning to private toll roads, including some urban roads — which are better candidates for profitable toll finance in nations with low automobile usage [Johansen (1989), Gómez-Ibáñez and Meyer (1993)].

The advantages of private operation are considerable. By tapping private sector investment funds, problems with raising and monitoring public funds are avoided and the returns from potential road projects may be more accurately weighed against those from other private investments. Lower costs are another possibility, although the evidence for them is limited [Gómez-Ibáñez and Meyer (1993), pp. 201-203]. Pricing structures that may be politically or legally infeasible for a public roadway are sometimes possible for a private enterprise. Other quite unexpected forms of innovation, such as novel construction methods and routes, may occur as happened in several California proposals. Environmental or other objections to specific sites may in some cases be overcome by private entrepreneurs with the flexibility and motivation to do so; and if a project appears too vulnerable to delay to be economical, the private company may be quicker to cut its losses and abandon the project.

On the other hand, private ownership may cause an inefficient allocation of traffic between the private toll road and any competing free or nearly free alternative routes, in that too small a portion of traffic may be carried by the private highway. This is especially a problem where tolls are high, as in Spain and Mexico [Gómez-Ibáñez and Meyer (1993), pp. 141-142, 156-157]. Furthermore, in the presence of free roads the investment signals provided by profitability of a proposed new road link may not accurately reflect its overall effect on welfare [(Mills (1995)].

A different problem arises where the private highway has considerable monopoly power, forcing authorities to deal with difficult issues of regulation. Will the potential efficiencies of unregulated private enterprise be realized if competition is lacking? Can regulation be imposed without destroying the advantages of flexibility and innovation? For example, given the resistance to time-of-day pricing of public highways, how likely is it that a public regulatory body would permit such a pricing structure on a regulated highway?

On the last question, there are only two cases so far of toll roads where congestion pricing is used. One is on the French Autoroute A1 southbound from Lyon to Paris, which is operated by a publicly owned but independent road corporation; here a revenue-neutral time-of-day differential on Sundays only was introduced successfully in 1992 [Gómez-Ibáñez and Small (1994), ch. 5]. The other is the new toll HOV lanes, mentioned earlier, that were built in the median of the existing Riverside Freeway (State Route 91) in the Los Angeles region. A private consortium built these lanes under a franchise agreement with the State of California which allows the consortium flexibility to adjust its time-of-day pricing schedule subject only to a cap on its overall rate of return [Gómez-Ibáñez and Meyer (1993), pp. 173-176; Fielding (1994)].

The form of franchising is crucial to reaping the advantages of pricing flexibility. European nations and developing nations have typically regulated toll rates, leading to the usual problems of political interference with economic decisions. For example, France developed an elaborate system of cross subsidies both within and across its toll road operating companies, public as well as private; as a result investment decisions do not face any real market discipline, and all but one of the privately owned road corporations have become public. In contrast, California adopted rate of return regulation on its private highways, which in theory should preserve more incentives for efficiency. Fielding and Klein (1993) explore alternative arrangements, using California as an example. While they argue that the bidding process could have been improved by making it more standardized, the somewhat open-ended solicitation actually used had the advantage of promoting innovative proposals. Clearly the best franchising or regulatory framework will depend in complex ways on the specific local context. This is a topic ripe for research using tools from the fields of industrial organization and of law and economics.

3. Motor Vehicle Air Pollution

The environmental costs of motor vehicles are another great concern. The air pollution problem is especially well documented and motor vehicles are important contributors to it. In Europe and the United States, motor vehicles typically account for 32 to 98 percent of national emissions of carbon monoxide (CO), volatile organic chemicals (VOCs, primarily hydrocarbons), and nitrogen oxides (NO_x) [Small and Kazimi (1995), Table 1]. Transportation also accounts for an important fraction of emissions of "greenhouse gases," especially carbon dioxide (CO_2), which are believed to be having significant long-term effects on the earth's climate [Cline (1991)]. Resulting policy issues are discussed by many authors including Small (1991), Button (1993), Hensher (1993), Whitelegg (1993), and Harrington et al. (1995).

3.1 Damage Estimates

The environmental costs of motor vehicles are hard to measure, but some estimates have been made. As one would expect, they vary according to local conditions. Quinet (1994, p. 58), reviewing studies from Europe, Australia, and the United States, reports that estimated aggregate social costs average around 0.3 percent of gross national product for noise and 0.4 percent of GNP for local air pollution (here "local" means excluding global warming). Small and Kazimi (1995) estimate health costs from local air pollution caused by the average on-road automobile in the Los Angeles region in 1992 to be $0.03 per vehicle-mile using middle-range assumptions. Costs of truck emissions are higher by a factor of nearly 20. As might be expected, these estimates for Los Angeles are moderately higher than estimates for average U.S. metropolitan areas as reviewed by Small (1991, p. 221) and as contained in a careful study by McCubbin and Delucchi (1995). About three-fourths of the Small-Kazimi cost estimate is from increased mortality due to inhalable particulates, both those directly emitted and those indirectly formed in the atmosphere from VOCs, NO_x, and sulfur oxides (SO_x). The rest of the costs are due mainly to minor illnesses from ozone, which is formed in the atmosphere from VOCs and NO_x.

Estimates of the global warming damages from greenhouse gas emissions have also been made, although such estimates are fairly speculative given the extreme scientific uncertainty and the very long-term nature of the effects. Some idea of the possibilities can be obtained from an indirect approach, however. Recently negotiated international agreements have focused on achieving certain concrete reductions in the time path of carbon dioxide emissions which appear to place an upper bound on the magnitudes of costs that policy makers are now willing to take into account. One such scenario involves stabilizing CO_2 emissions at 1990 levels by the year 2000 and at 20 percent below those levels by the year 2010. Manne and Richels (1992) estimate the marginal CO_2 reduction costs that are implied by such a scenario for the U.S. The marginal cost rises over time, then stabilizes at around $208 per ton of carbon (1990 prices). This is more than twice the size of a carbon tax proposed but never implemented in the European Union, and is also within the range of other estimates of carbon taxes required to meet various reductions [Quinet (1994), p. 49]. Updated to 1992 prices, this figure is equivalent to 3.1 cents per vehicle-mile for an auto with the 1992 U.S. average fuel economy [Small and Kazimi (1995), p. 28].

Environmental policy toward air emissions has been only partially successful. In the United States, air quality has improved steadily since the 1960s but targets for achieving health-based standards have slipped by decades and there has been little improvement in ozone, for which motor vehicles bear substantial responsibility [Calvert et al. (1993), Harrington et al. (1995)]. Europe has lagged behind the United States in emission controls on motor vehicles [Small and Kazimi (1995), pp. 9-11]. In Japan, high population densities and levels of automobile usage make air pollution a continuing problem. Tangible policies bringing about significant reductions in CO_2 emissions have yet to be realized in any part of the world.

3.2 The Relationship between Congestion and Pollution

Certain transportation policies might reduce both congestion and air pollution since both problems are related to vehicle use. Such policies might also enjoy a broader base of political support (Rom, 1994). However, policies aimed broadly at reducing overall vehicle use often do little to reduce either congestion or pollution while policies that are well targeted toward one of these problems often address the other only poorly [Hall (1995)]. The problem is that congestion is specific to location and time, whereas pollution emissions are specific to vehicle characteristics and driving behavior.

Simulations suggest, for example, that congestion pricing could reduce air pollution but not by enough to excite most environmentalists. Harvey (1994) estimates that fairly high congestion charges in the San Francisco and Los Angeles areas would reduce motor-vehicle VOC emissions by only 5.5 and 8.2 percent and CO_2 emissions by 6.5 and 9.2 percent, respectively. The primary effect of congestion charges is to shift traffic from peak to off-peak rather than to eliminate it altogether. Conversely, emission charges have rather small effects on congestion because they encourage reduced emissions per mile more than reduced travel.

Planners are also less hopeful than before that reductions in congestion will reduce average emissions per vehicle mile. It is true that CO and VOC emissions are higher in stop-and-go traffic. NO_x emissions tend to increase with average speed, however, as do CO and VOCs emissions at speeds above those characteristic of moderately congested expressways. Furthermore, there is great statistical uncertainty in the relationship between emissions and speed, especially for increases from moderate to high average speed [Guensler and Sperling (1994)].

Probably the safest conclusion is that congestion and pollution policies tend to reinforce each other, but that specific measures targeted toward each goal are necessary for success. Once such measures are identified, it may make political sense to package them together.

3.3 Technological Controls

Nearly all of the reductions in motor vehicle air pollution achieved so far have been due to mandated reductions in emission rates per vehicle mile. In the United States, which requires the most stringent controls, 1993 model year new cars must emit 95 percent fewer VOCs and CO per mile and 75 percent fewer NO_x emissions than 1968 model year new cars. California's standards are even stricter, and the schedule fixed by the Clear Air Act Amendments of 1990 continues a policy of significant reductions. In-use emissions from the fleet at large have declined by smaller but still impressive amounts, at least according to the most recent federal estimates [Calvert et al. (1993), pp. 38-39)].

Further tightening of the already low legal emissions standards may not accomplish much. The problem is that the remaining emissions appear to be dominated by three factors that are missed by current enforcement mechanisms. First, a substantial fraction of total emissions now comes from a relatively small number of vehicles, known as "gross polluters," with malfunctioning emissions control systems. Second, large emissions occur during brief episodes in ordinary driving which are inadequately represented in the test procedures, such as rapid acceleration when entering expressway traffic.[5] Third, inspection and maintenance programs fail to accurately identify vehicles out of compliance or to elicit adequate repairs when such vehicles are identified.

Further tightening of emissions standards may have little or no effect on these sources of emissions, which are caused by a combination of the inherent complexity of automotive technology, fraud or laxity during inspections, tampering by vehicle owners, and the limitations of test procedures [Glazer et al. (1995)]. Furthermore, it is now recognized that previous estimates understated aggregate VOC emissions from mobile sources by a factor of two or three [Small and Kazimi (1995), pp. 11-12]. This, in turn, misled policy makers to rely excessively on controlling VOCs instead of NO_X as the means of reducing ozone, since the chemistry of ozone formation depends critically on the ambient ratio of VOCs to NO_x [National Research Council (1991)].

It is now possible to measure actual emissions by cars on a highway by measuring light absorption from a roadside laser beam. This technology appears accurate enough to improve existing vehicle inspection programs by, for example, using random roadside screenings to identify vehicles in need of a more thorough inspection [Glazer et al. (1995)]. It is even possible that such technology could eventually become the basis for direct emission charges.

[5]These episodes are known as "off-cycle" or "open-loop" events. For careful documentation, see Calvert et al. (1993) and references in Small and Kazimi (1995).

Another technological approach is to reformulate fuel in order to lower emissions. This policy, which is included in the U.S. Clean Air Act Amendments of 1990, has the advantage that it immediately improves emissions from the entire fleet, not just new cars. Its disadvantages include large investments for refinery conversion and the danger of creating maintenance or performance problems in vehicles designed for different fuel mixes.

Other possibilities include introducing of "alternative fuel vehicles" that run on methanol, ethanol, compressed natural gas, electricity, or other more exotic fuels. Such alternative fuels offer one way to reduce emissions, although not necessarily across the board. They also raise new problems such as toxic formaldehyde emissions from methanol and the safe disposal of lead and/or cadmium from current-generation electric batteries [Lave et al. (1995)].

The most drastic approach is to require a proportion of vehicles sold to have zero emissions. California law requires that specified percentages of "zero-emission vehicles" be phased in by vehicle manufacturers, and several other states in the northeast have announced a similar approach. In practice this requirement, if maintained, will require electric cars (whose off-site emissions at the power source are not counted). Aside from the question of whether "zero" has any defensible scientific meaning as an emission standard, this regulation is clearly based on a belief in a particular technological solution, and it may ignore some complex behavioral adaptations. For example, electric cars have a shorter range so households purchasing them might use their other, older cars more often [Kazimi (1995)].

Harrington et al. (1995) examine the cost-effectiveness of various policies applied to the United States as a whole. Cost-effectiveness is measured, somewhat narrowly, as cost per ton of VOCs removed. Reformulated gasoline and inspection and maintenance programs are relatively cheap ($1,900 to $6,000 per ton VOCs removed). The tighter emission standards being implemented by California cost about the same or as much as ten times more, depending on assumptions. Alternative fuel vehicles are the most expensive, with electric vehicles estimated to entail a cost of $29,000 to $108,000 per ton VOCs removed. As a point of comparison, the health costs estimated by Small and Kazimi (1995, table 5) for the Los Angeles region come to $2,920 per ton VOCs, with a range of $1,240-$4,080 under various alternative assumptions.

3.4 *Transportation Control Measures*

Clean air legislation promotes several of the TDM policies also used for congestion relief. In the clean air context they are usually called "transportation control measures," or TCMs, a designation in the U.S. Clean Air Act. Hall (1995), who finds, as we do above, that TCMs have only limited ability to reduce motor vehicle travel compared with pricing policies. Employer-based policies are especially ineffective in controlling pollution because work trips are an even smaller proportion of total travel (less than one-fourth in the United States) than they are of peak-period travel.

3.5 *Pricing Policies*

In theory, one might charge motorists for local air pollution on the basis of actual vehicle emissions in use. Assuming this will not be feasible for some time, an approximation would be a fee proportional to distance travelled, with the rate determined by the estimated emissions rates (as measured, for example, by an annual test of the vehicle or by the manufacturer's new-vehicle test results). This proposal would not eliminate the need for more reliable inspections, but it would strongly encourage drivers to minimize their use of high-polluting vehicles. For CO_2 emissions, the most direct pricing policy would be a fuel tax whose rate is based on the carbon content of the fuel.

Harvey (1994) tests distance- and emissions-based pollution fees in his San Francisco and Los Angeles simulations described earlier. He finds the pollution fees less effective than congestion pricing, probably because the pollution fees he considers are rather small: in Los Angeles, the simulated pollution fee averages $110 per year per vehicle, while the congestion fee averages $0.15 per mile or about $370 per year per vehicle.[6]

Similarly, Harvey's simulations suggest that pricing employee parking is a rather ineffective means of pollution control, achieving emission reductions of only around 1.4 to 2.1 percent from charges of $3 per day. Presumably this is because the policy affects only the minority of trips that are to or from work, and because it fails to discourage new trips from taking advantage of any improvement in travel conditions.

Finally, Harvey (1994) also tests a gasoline tax increase of $2 per gallon in his San Francisco simulations. Such a tax is equivalent to $670 per ton carbon,[7] more than twice the amount implied by international agreements for CO_2 reduction discussed above. The gasoline tax increase costs the average vehicle owner around $1,000 per year[8] and thus is predicted to

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[6]This is based on an estimated 21.4 percent of annual vehicle-miles being subjected to the average charge of $0.15 per vehicle mile [Small (1992b), p. 371], and annual usage of 11,600 miles per vehicle, the U.S. average for 1993 [AAMA (1995), p. 66].

[7]This is based on one ton carbon content for every 335 gallons of refined petroleum product, calculated from Manne and Richels (1992, p. 59).

[8]Based on average annual fuel consumption of 513 gallons per year for U.S. passenger cars 1993 [AAMA (1995), p. 66].

have fairly significant impacts on both vehicle-miles of travel (reduced by 8.1 percent) and on emissions (VOC, CO, and NO_x all reduced by around 7.7 percent). The gasoline tax is still a rather blunt instrument for dealing with local pollution, however, because it is not emissions-based. The tax is best targeted for CO_2 control, and elicits an estimated 36 percent reduction in CO_2 emissions. This reduction is more than four times the estimated reduction in total vehicle travel because motorists shift toward vehicles and driving patterns that are more fuel-efficient.

Harrington et al. (1995) examine the cost-effectiveness of emissions-based fees as well as the regulatory policies described earlier. They find the fees to be considerably less costly — $1,650 per ton of VOCs removed — than any other policies considered, with the exception of congestion pricing (which they regard as costless because it produces travel-time benefits).

Koopman (1995) simulates the effects of policies calibrated to reduce CO_2 emissions in Europe by 10 percent by the period 2010-2015, using a model system known as EUCARS. One policy is a carbon tax that implies a 21 percent rise in average gasoline prices. This is compared with three other policies also aimed directly at fuel consumption — fuel taxes, "gas-guzzler" taxes, and fuel economy standards — and with car ownership taxes. The policies aimed directly at fuel consumption are found to have very similar overall welfare costs, with carbon tax having a slight edge. Car ownership taxes are much worse, imposing welfare losses nearly three times as high. The effects on household behavior are also very different. Taxes on car ownership tend to reduce car ownership, naturally enough. With carbon taxes and other measures aimed directly at fuel use, however, car ownership and use fall only 3.3 and 4.3 percent, respectively. Households respond instead largely by shifting to more fuel-efficient and smaller vehicles in order to reduce fuel use per vehicle-kilometer. The fuel or carbon taxes are a relatively minor share of total costs of owning and using cars to begin with, and their share is reduced by the shift to fuel-efficient vehicles [Greene (1992)], further diminishing the incentive to own fewer cars or drive them less.

Another pricing policy is marketable permits, which under certain conditions provides incentives equivalent to those of emission fees. A variety of marketable-permit schemes have been developed e.g., [Hahn (1989)], but none have been applied to mobile sources.

3.6 Conclusion

Estimates suggest that the marginal social costs of motor-vehicle use due to air pollution are much smaller than those due to congestion, at least during peak periods in urban areas. Thus, if motorists had to pay for the air pollution damages they cause the total costs of driving would rise very little for most people and total vehicle travel would be little affected. This finding implies that measures to reduce emissions per vehicle mile are likely to be the most efficient means of motor vehicle air pollution control.

The principal measure for reducing emissions per vehicle mile to date has been to set maximum emissions standards for new vehicles. This has worked reasonably well so far, but further progress will require stronger incentives on individual vehicle owners to maintain their vehicles so as to keep emissions low. This moves policy in a behavioral direction, which most nations have been reluctant to do.

The problem of global CO_2 pollution is rather different and far more uncertain. Nevertheless, current evidence does not provide a compelling case for drastic across the board reductions in vehicle travel. Rather, incentives for fuel conservation seem called for, and the evidence suggests that the primary response would be through improved fuel efficiency of vehicles. Once again, a technical solution underlies the most likely effective approach.

4. Motor vehicle Accidents

Economists have paid much less attention to the problem of motor vehicle accidents than to congestion and pollution despite the fact the aggregate costs of accidents appear to be far higher than those of pollution and comparable to congestion costs even in urban areas [Small (1992), table 3.2]. Economists may have focused on congestion and pollution because it is clear that they are externalities, while accidents are not necessarily so. These issues and others in the evaluation of motor vehicle accidents make the subject fascinating and potentially very productive for economic analysis.

4.1 Magnitude of Accident Costs

In a widely cited and comprehensive study, Miller (1993) estimates that accidents cost the United States $333 billion in 1988, or an average of $0.164 per vehicle-mile.[9] In another careful study, Newbery (1988) estimates total 1984 accident costs in Britain at £26 billion (in 1986 prices) or $0.22 per vehicle-mile.[10] These U.S. and U.K. estimates correspond to 7 and 5 percent

[9]Total motor vehicle travel in the U.S. in 1988 was 2,025.6 billion vehicle-miles, according to U.S. FHWA (1988), table VM-1.

[10]This applies the 1986 exchange rate of US$1 = £1.47, from U.S. Council of Economic Advisors, *Annual Report*, 1995, in: *Economic Report of the President*, Feb. 1995 (Washington: U.S. Government Printing Office), table B-112. Vehicle-kilometers traveled are inferred from Newbery's tables 4-5 to be 273.8 billion.

of gross national product, about three to four times higher than the typical estimates of 1.5 to 2 percent found by Quinet (1994 pp. 37-39, 58) in a review of other studies in Europe and the United States. All of these accident estimates exceed typical estimates for aggregate congestion costs in part because they include rural areas, where accident costs are quite high because higher rural traffic speeds increase accident severity.

Accident costs are not as heavily dominated by fatalities as are air pollution costs. Fatalities account for only 34 percent of Miller's U.S. estimates; non-fatal injuries account for 53 percent (brain injuries being the largest category), and property damage and time delays account for the remaining 13 percent. In Newbery's U.K. study, fatalities and serious injuries each account for 49 percent of the estimate. The difference may be that Newbery used a value of life about 50 percent higher than that used by Miller. Neither study includes insurance administrative costs, which elsewhere have been found to be very large in the United States, perhaps two-thirds as large as all property damage [Small (1992), p. 78].

Traffic accident fatalities per vehicle-mile have dropped steadily in the United States for many years, falling by 58 percent from 1972 to 1993 [U.S. Census Bureau (1995), table 1033]. The reduction is thought to be due to a combination of changes including road improvements, efforts to discourage drunk driving, and safety improvements to vehicles. Some would also credit the national 55 mile per hour speed limit enacted in 1974 and repealed in 1996, although Lave (1985) argues that it had little if any positive effect because accident rates are more closely related to variance in speed than to average speed.

4.2 Issues in Valuation

Economists have clarified a number of conceptual issues in valuing safety improvements over the years. The most important is the idea of valuing the health consequences by the aggregate of individuals' willingness to pay to reduce the risk of injury or death from accidents. This is now well established in the literature, and replaces the less justified practice of measuring the market value of lost production. The empirical measurement of willingness to pay, particularly for reduction in risk of death, is reviewed by Kahn (1986), Jones-Lee (1990), and Viscusi (1993), among others. The studies with the best controls for bias seem to yield values for developed nations on the order of $1.5 to $9.0 million per statistical life, i.e., $1.50 to $9.00 for a marginal increment of 1 per million in risk of death. Just how this varies across population groups is an unsettled issue which could have an important bearing on questions such as valuing motor vehicle accidents, which kill people across the age spectrum, relative to air pollution, which tends to kill older people from cancer and respiratory diseases.

A second issue is whether to add to the individual's willingness to pay an additional amount reflecting the concerns of family and friends. Jones-Lee (1990) suggests that this could add 40 or 50 percent to the "value of life." There are two arguments for not doing so, but neither is definitive. The first, due to Bergstrom (1982), is that family and friends may place value on the individual's utility rather than just on her health, in which case they would not want to alter her own tradeoffs between health and money:

> to push values of safety beyond the level implied by people's willingness to pay for their own safety would result in an 'overprovision' of safety relative to the other determinants of their utility. [Jones-Lee (1990), p. 42]

Empirical evidence is needed to decide the extent to which family and relatives' altruism is health-specific. The second argument is that the individual may already take her family and friends' valuation into account in her own tradeoffs so that they are already reflected in the empirically measured values.

Actual practice in valuing statistical lives for purposes of cost-benefit analysis in Europe is summarized in Quinet (1994) and analyzed in EC (1994).

4.3 The Demand for Safety

Empirical research has established that people are willing to pay for safety improvements. Examples include studies of the demand for specific safety features on vehicles [Arnould and Grabowski (1991), Mannering and Winston (1995)], for an index of crash worthiness [McCarthy (1990)], and for vehicle models with good records of actual safety outcomes [Winston and Mannering (1984)].

A related aspect of consumer behavior is the extent to which people may compensate for safer vehicles by engaging in more dangerous behavior — or equivalently, the extent to which they offset safety hazards by being careful. Peltzman (1975) posited that the potentially beneficial effects of government mandated safety features in new vehicles would be partially or fully offset because drivers would respond by driving more dangerously. Many researchers have tested this effect empirically including Chirinko and Harper (1993), who also provide a useful review. A common finding is that there is some substantial compensating behavior but not enough to fully offset the original safety improvement. Such studies are frequently plagued by problems of changing vehicle mix and by potential endogeneity of the variables measuring the use of safety equipment.

4.4 Externalities

One problem in estimating whether (or to what degree) accident costs are externalities is the lack of satisfactory empirical evidence on how accident costs vary with the volumes of auto and truck traffic. There are several distinct questions, all of which are research areas with great potential payoff.

How do accident costs vary with traffic volumes? The extent to which accident costs are externalities depends critically on the extent to which accident rates or severity are affected by traffic volume. Indeed, conceptually the problem is similar to that of congestion in that congestion constitutes an externality only to the extent that additional vehicles in the traffic stream reduces average traffic speeds [Jansson (1995)].

Like the relationship between traffic volumes and speeds, the relationship between volumes and accident rates could be a simple static one or it might depend in complex ways on the dynamics of traffic movements. It may be important to know how different vehicle types or driver behaviors affect costs. At the simplest static level, the question may be reduced to asking what is the elasticity of total accident cost on a road with respect to its traffic volume; if the elasticity exceeds one there is a negative externality because each user imposes costs on other users, causing social marginal cost to exceed private marginal cost.

Vickrey (1968) argues from impressionistic evidence for an elasticity of 1.5; Jones-Lee (1990) follows official British practice by assuming 1.0 (i.e., linearity); Newbery (1988) splits the difference at 1.25. The problem with measuring this elasticity is that traffic densities are highly correlated with time of day and degree of urbanization, both of which affect accident rates and severities strongly and, in the case of urbanization, in opposite directions — urban roads have more frequent but less severe accidents than rural roads. The elasticity could even be less than one if higher volumes reduce speed sufficiently, or if occasional traffic helps keep other drivers alert. Thus Fridstrøm and Ingebrigtsen (1991) find an elasticity of only 0.47 in their mostly rural sample from Norway.

How much of accident costs are borne by non-motorists? Pedestrians and cyclists appear to account for considerably more than half of motor-vehicle deaths in Britain, according to figures reported by Jones-Lee (1990, p. 51). In the United States they account for 16 percent [U.S. Census Bureau (1995), table 1033]. The government pays for some medical expenses through various programs of health care or indigent care. Both of these represent potential externalities if there is no compensation mechanism by which motorists are faced with these costs.

Does insurance affect users' perceptions of the accident costs resulting from their driving? It is typical for government publications to include insurance premiums as a fixed cost of driving, as for example in U.S. Census Bureau (1995, table 1038). The belief that people do not perceive these costs as variable underlies "pay at the pump" proposals to convert automobile insurance to a surcharge on the gasoline tax.

However, insurance companies attempt to vary their premiums as closely as possible with actual accident risk. For this reason, annual premiums often depend on age, sex, residential location, prior accident record, and distance traveled for daily commuting to work. The variation with past accident record is so strong that people sometimes pay damages themselves rather than report an accident to their insurance company, for fear of causing dramatic rises in future rates. Thus it is impossible to believe that people are unaware of these considerations. Just how they take the information into account is an empirical question with strong bearing on efficient externality fees. We would argue that where the private insurance market is allowed considerable freedom in varying premiums, the starting assumption should be that all insured costs are perceived as private variable costs by users unless specific evidence to the contrary is produced.

Note that efficiency does not require the user responsible for an accident to pay the actual costs of that accident, as would happen under a tort system with strict liability. All that is required is that the user perceive the *expected* social cost resulting from his or her use of the highway. The fact that the user can insure against the random component of accident cost is a legitimate function of insurance and need not interfere with efficient pricing.

If liability insurance is perceived as a variable cost, then the costs of injuries to pedestrians and bicyclists becomes internalized to the motorist to the extent they are reimbursed by the motorist's insurance policy. However, external costs due to a nonlinear dependence of accidents on traffic remain uninternalized, assuming insurance pays at most 100 percent of the cost of an accident. For example, if party B is fully compensated by party A's insurance because party A was legally liable for the accident, then the costs of that accident are removed from party B's perceived cost of driving; yet if B's presence on the highway contributes positively to the overall accident rate, efficiency requires that it be discouraged through some corrective policy such as Pigovian taxation. Under that scenario, such Pigovian taxes would generate more revenue than needed to compensate victims. Such revenue could help offset certain infrastructure costs that are undertaken for safety improvements rather than capacity enhancement.

How do tort and criminal law affect incentives? The legal system is another way that parties may be charged for accidents resulting from their driving decisions. The literature in law and economics provides a theoretical framework for analyzing such effects; see, for example, Calabresi (1970), Brown (1973), Shavell (1987), and Boyer and Dionne (1987). We are not aware of any empirical work that exploits these ideas in the area of accident costs.

Do people seek out a certain level of risk taking? It is possible that people who drive in an aggressive or dangerous manner are using the road system to express emotions that would otherwise find another outlet. The predominance of young males in accident statistics is certainly suggestive. If so, an evaluation of safety improvements would have to take into account how costly those alternative outlets of destructive behavior would be to society. If they are equally costly, the safety improvement has no net social benefit. To address such a question requires going well outside the usual framework of economic analysis to incorporate psychological motivations for behavior.

4.5 Conclusion

Accidents are one of the largest costs of motor vehicle use, and one that appears highly susceptible to public policy. Accidents almost certainly entail externalities, although their exact nature is largely unknown. Valuing accident costs involves sophisticated concepts and difficult empirical challenges, but researchers seem to be succeeding. The behavior and technology that produce accidents interact strongly with insurance and legal institutions, adding to the challenge of performing accurate analysis of incentives and policy effects.

Three topics seem both important and feasible areas for fruitful economic analysis. The first is exactly how accident rates and severity vary with traffic volumes. The second is how people perceive insurance costs, and whether any institutional changes could make those perceptions more consonant with efficiency. The third is the incentives produced by the legal system.

The historical evidence suggests that there is considerable room for addressing accidents with technology and targeted behavioral incentives. We suspect that efficient policies would lead to various adjustments in vehicle mix, technology, and driving behavior. At this point there seems little reason to believe that the costs of driving would dramatically rise or that people would adjust by markedly reducing their use of motor vehicles.

5. Public Transportation

One of the long-standing issues in transportation is the appropriate balance between urban public transportation and the automobile. The term public transportation typically refers to modes that offer service for hire to the general public, such as buses, streetcars, subways, and commuter railroads. By contrast, private modes, such as the automobile, are generally available for the use of only one travel party at a time. Although some researchers include taxis among the public modes on the grounds that they are available for hire to the general public, the more general practice is to consider taxis separately, as something of hybrid. Public transportation services may be provided by either private firms or public agencies.

We address a number of issues that have been the topics of intense research and debate. First we examine current trends and patterns of public transportation ridership, and alternative explanations for them. Next we consider whether it is desirable to subsidize public transportation in order to compensate for the external costs of the automobile or for other reasons. We then take up a question that has great practical importance and continues to provoke controversy: in what circumstances is rail better than bus at providing urban mass transit services? Next we examine quasi-public and flexible modes known as paratransit. Finally, we review and evaluate current moves to rely more heavily on private companies and deregulated markets.

5.1 Trends in Ridership and Subsidy

Many of these issues have become pressing because public transportation ridership has been declining for decades in the United States and many other developed countries. The situation in the United States has been particularly well documented, for example, by Altshuler et al. (1979), Meyer and Gómez-Ibáñez (1981), and Wachs (1989). In the United States, ridership began to decline after World War I as postwar prosperity brought the first major surge in auto ownership. The decline was interrupted by World War II, when fuel and tires were rationed, but resumed immediately after. By the 1960s many of the private firms that had provided public transportation services were bankrupt or nearly so.

The threat of further deterioration or outright abandonment of services brought popular pressure for subsidies, usually accompanied by public takeover. In 1964 the federal government began a program of grants for capital expenses, which is alleged to have encouraged the wave of municipal takeovers [Hilton (1974)]. In 1974 federal grants were made available to cover operating expenses as well. These federal infusions supplemented state and local taxes, which remained the predominant form of operating aid.

By 1973 the decline in ridership had been halted, probably thanks to a combination of growing subsidies and the oil shortages which began that year. Subsequently aggregate ridership has grown. Between 1972 and 1992, reported trips by public mass transit increased by 62 percent nationwide (from 5,253 million to 8,519 million trips per year), although part of this increase (perhaps 600 million) was due to changes in reporting procedures.[11]

Meanwhile subsidies soared. In constant 1992 dollars, the average operating subsidy per passenger trip increased from $0.18 in 1970 to $1.43 in 1992 [Perl and Pucher (1995, Table 2)]. Farebox revenues covered only 41 percent of operating expenses and 31 percent of total expense by 1992.

Even though ridership has increased, automobile use has increased faster, so that public transportation's share of all trips has continued to decline. According to U.S. Census statistics, for example, the percentage of all workers using public transportation fell from 12.6 in 1960 to 5.1 in 1990 [Rossetti and Eversole (1993, p. 2-2)]. In the 39 largest metropolitan areas, the percentage of workers commuting by bus or rail transit or by commuter railroad fell from 11.2 in 1980 to 8.7 in 1990 [Rossetti and Eversole (1993, pp. 5-11 and 5-12)].

Western Europe, Great Britain, Canada, and Australia appear to be suffering from similar adverse trends in public transit usage and profitability, although ridership per capita is still much higher than the United States [Pucher (1988, p. 511)]. Pucher and Kurth (1995, p. 118) report that between 1980 and 1993 transit ridership declined in Britain, Italy, Norway, and West Germany, but increased in Austria, Canada, France, and the Netherlands. In Canada, however,

[11]See American Public Transit Association (1993 p. 64). The main problem in reporting transit ridership is the distinction between linked and unlinked trips. An unlinked trip consists of a ride on one transit vehicle, whereas a linked trip may include two or more vehicles connected by a transfer. Measuring patronage by unlinked trips creates misleading comparisons whenever there is a change in the proportion of travelers who transfer, such as occurs upon the introduction of a rail transit system supplemented with feeder buses.

1990 was a peak year: absolute ridership fell 11 percent and per capita ridership fell 20 percent in the next four years [Perl and Pucher (1995), table 1].

Throughout Western Europe, Canada, and Australia urban public transit is heavily subsidized by the taxpayer [Pucher (1988, p. 511)] and the level of subsidy is growing in many countries. Indeed, the growth of subsidies is probably the major reason why public transit ridership is still increasing in some of these countries. To give just two examples, annual real subsidies grew by 45 percent in Canada between 1980 and 1992, with ridership growing just 7 percent [Perl and Pucher (1995), table 2]. In West Germany between 1980 and 1993, annual subsidies increased by 67 percent in real terms while ridership held essentially constant [Pucher and Kurth (1995, pp. 118 and 126)].

Even where public transit ridership has stabilized or increased, moreover, car ownership and use are increasing faster. Pucher (1995a, p. 101) reports that during the decade of the 1980s private car ownership per capita increased faster in almost every European country than in the United States, albeit from a smaller base. Sharman and Dasgupta (1993) found in a survey of 93 European cities that private car traffic increased by 30 to 35 percent per decade in the 1970s and 1980s.[12] As a result, public transportation's share of total trips is declining in Europe as in the United States.

Analogous trends are evident in the newly emerging economies of Eastern Europe and in the developing countries of Asia, Latin America, and Africa. Pucher (1995b, p. 220) examines four Eastern European countries, for example, and finds that between 1985 and 1993 public transportation ridership fell dramatically in three (East Germany, Hungary, and Poland) and rose

[12]As reported by Pucher (1995a).

in only one (Czechoslovakia). In the developing world, trends are more complex. Transit ridership in the poorest countries is growing fairly rapidly as the population shifts from human or animal-powered modes to motorized modes, primarily bus. In the large cities of such countries, public transportation often accounts for 80 percent or more of all motorized trips, although a much smaller share of total trips. Among the richer developing countries, however, the transition to motorized forms of travel is nearly complete and the shift between public transportation and the automobile has begun in earnest. Public transportation ridership is often still stable or growing slowly, usually without the aid of significant subsidies. But auto ownership and use is growing far more rapidly so that public transportation's share of motorized trips, although still higher than in Europe, is falling steadily.

5.2 *Explaining Ridership Trends and Patterns*

One interesting question is whether the long term decline in public transportation ridership in the United States and elsewhere is the result of income growth, demographic trends, and other structural shifts in the economy or a consequence of public policies that, intentionally or not, favor the automobile and handicap public transportation. A related question is which of these factors account for differences across countries.

Most researchers agree that rising incomes and the suburbanization of jobs and residences have had powerful effects. Rising real incomes make the door-to-door convenience, privacy, and amenities of the automobile more affordable, while also making labor-intensive services such as transit more costly. Suburbanization of jobs and residences produces a dispersed pattern of travel that is difficult for conventional public transportation to serve.

A variety of empirical evidence supports this theoretical reasoning. Time-series studies consistently suggest that income growth and urban spatial structure are important determinants of ridership. For example, Gómez-Ibáñez (1996) found that ridership changes in the Boston metropolitan area during the 1970s and 1980s could be explained largely by changes in transit fares and services, real incomes per capita, and the number of jobs in the central city. The statistical analysis implies that in those two decades, when there was little new highway construction in the metropolitan area, Boston's transit ridership would have declined by 10 to 15 percent if public officials had not reduced fares and improved services. Kain (1994), Liu (1994), and Kyte et al. (1988) obtained similar results in time-series analyses of ridership in Atlanta and Portland, Oregon.

Cross-sectional studies also show that differences in transit ridership are strongly associated with income and spatial structure. Gordon and Willson (1984) examine an international cross section of 91 cities with light rail lines, finding that ridership is strongly related to city population density and per capita gross national product. Hendrickson (1986) finds that most of the variation in transit ridership across U.S. cities is explained by differences in the number of jobs in the central business district. Analyses of micro data on households also show that household income is a major determinant of travel mode and automobile ownership; the income elasticity of transit usage is typically estimated at -0.5 or higher when car ownership is treated as endogenous, as it should for this purpose.[13]

[13]Lower absolute values of this elasticity are sometimes estimated in models that include car ownership as well as income variables; but since car ownership itself responds strongly to income the full effect on transit ridership is larger [Berechman (1993, p. 38)].

What is the scope for currently available policies to significantly alter the broad trends working against transit as a dominant urban travel mode? On such policy is to raise fuel taxes. Pucher (1988, 1995a, 1995b) concludes from a detailed country-by country comparison that Europe's high gasoline taxes are a primary factor in explaining its high transit usage. However, this inference appears to be overturned when multivariate statistical techniques are used. Wheaton (1982) shows that if one controls for differences in income and other variables, Europeans respond to higher gasoline taxes largely by buying more fuel efficient vehicles rather than by owning fewer cars or driving less. Wheaton's finding is consistent with the simulations of the effects of congestion tolls and other measures by Harvey (1994) and Koopman (1995) discussed in section 3.4.

Another possibility is to promote land use patterns more supportive of public transport use. Newman and Kenworthy (1989) and others have often argued that the higher transit usage in European cities is due to higher densities, and that increasing densities would increase transit usage. As noted earlier in section 2.3, however, other factors besides land use are involved and it may not be desirable or feasible to force households and firms to denser locations to achieve only small reductions in auto use.

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5.3 *The Pros and Cons of Subsidy*

The most obvious method of arresting the decline in transit usage, and the one most widely adopted, is to subsidize transit. These arguments are often advanced in support of such subsidies. The first is that motorists do not pay the full marginal social costs of auto use, and thus transit subsidies are necessary to insure that travel choices between public and private modes are not distorted. The better solution would be to price auto use properly, of course. But if it is administratively difficult or politically impossible to correct the mispricing of auto use, then subsidizing auto's competitor, public transportation, may be a useful second-best corrective.

The second argument is that public transportation is characterized by economies of scale so that fares set at marginal cost will be insufficient to cover total cost. Scale economies are more likely in rail transit than bus transit if only the costs of the public transportation firm are considered. Cost functions of bus firms show only modest economies of scale and then only for very small firms or firms that have excess capacity [Berechman (1993, pp. 120-127)]. In contrast, cost functions for rail transit and for multimodal enterprises generally show economies of scale, traffic density, or scope [Berechman (1993, pp. 127-128); Viton (1992)].

Economies of scale can be found in bus as well as rail, however, if one includes the value of time spent by the travelers. The reason is that greater passenger densities permit some combination of more frequent service, greater vehicle utilization, and more direct routes.[14] This effect is so pronounced that some simulation models have predicted surprisingly large modal shifts to public transit resulting from simultaneous marginal-cost pricing of peak auto and transit trips [Viton (1983)]; the initial effect of much higher peak auto prices is further accentuated by resulting improvements in transit service quality and/or fare reductions.

The final argument for subsidies is that poor and disadvantaged households tend to be more dependent on public transportation than the rest of the population. Subsidies therefore may be an important means of aiding these groups or insuring that they have a minimum level of mobility needed to participate in society.

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[14]See Mohring (1972), Turvey and Mohring (1975), Nash (1992), and Jansson (1993).

However, transit subsidies bring their own problems.[15] First, public transportation demand is not sensitive enough to price or service improvements for small subsidies to do much for allocative efficiency. Estimates of the direct price elasticity of demand generally range from -0.1 to -0.5 in developed countries with many studies reporting results around -0.3; the elasticity of demand with respect to travel time, service frequency, or service miles is perhaps a bit higher in absolute value but less than one.[16] Estimates of the cross elasticity of demand for auto trips with respect to public transportation fares or service are even smaller because only a fraction of transit riders are diverted from autos and because the starting base of auto use is so large [Kemp (1973)]. For example, estimates of cross-elasticities for eight Australian cities are all less than 0.02 in absolute value [Dodgson (1986), Table 4]. The modest direct elasticities suggest that the efficiency gains from pricing at marginal cost instead of average cost in the face of increasing returns to scale may be modest. The even smaller cross elasticities suggest that transit subsidies are a costly way to correct for the mispricing of auto use.

Another difficulty is that many public transportation riders are not poor or disadvantaged, making such subsidies a poorly targeted income distribution measure [Meyer and Gómez-Ibáñez (1981)]. In the smaller and less congested U.S. metropolitan areas the majority of transport users are generally too poor to own a car or too young, elderly, or infirm to drive [Pucher et al. (1983)]. In larger and more congested metropolitan areas, many public transportation riders are commuters to the central city, who are wealthier than the average metropolitan resident. In both

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[15]See Wachs (1989) for an insightful review.

[16]See Goodwin (1992 p. 160), Oum et al. (1992, p. 148), Chan and Ou (1978), and Berechman (1993, pp. 38-39).

small and large metropolitan areas, moreover, many poor households own cars or use taxis because public transportation, despite subsidies, does not serve well the trips they need to make.

Perhaps the most serious problem with subsidies is that a large portion of them is absorbed in reduced productivity or higher wage rates rather than contributing to improved service or fares. This is supported by both cross-sectional and time-series studies of transit firms receiving different levels of subsidy. For example, Bly et al. (1980) examine data on transit subsidies and performance in 59 cities in 17 developed countries between 1966 and 1976. Their analysis suggests that a one percent increase in subsidies was associated with a 0.4 to 0.6 percent increase in the real costs of providing a vehicle-mile of service. They also test specifications in which either the subsidy or productivity variables are lagged; the model performs better when the subsidy variable is lagged, suggesting that the causality was from subsidies to costs rather than vice versa. Anderson (1983), Pucher et al. (1983), and Perry and Babitsky (1986) find similar results in analyses of cross-sections of U.S. public transportation companies, as does Cervero (1984) for a pooled time-series cross-section of California transit systems.

Pickrell (1985a) uses simple accounting identities to calculate how the increase in public transportation subsidies in the United States between 1970 and 1980 was used. His calculations show that 61 percent of the increase in real (net of inflation) subsidies resulted from an increase in the real cost of providing a vehicle-mile of service, while only 14 percent was used to reduce real fares and 9 percent to increase the number of vehicle-miles of service offered.

Lave (1991) examines costs using annual data from 62 large U.S. bus firms. He finds that unit costs increased by an average of 1.4 percent per year in the era before federal subsidies were available (1950-1964), compared to 2.1 percent per year during the decade of federal capital grants (1965-1974) and 3.1 percent per year when the federal government subsidized both capital and operating expenses (1975-1985). Larger firms experienced more cost inflation, suggesting to Lave that workers at such firms may have used their cities' vulnerability to transit strikes to extract more of the subsidies in the form of higher wages.

There is some evidence that the rate of increase in unit costs has slowed in the last decade, perhaps because taxpayers have become more reluctant to finance subsidy increases. For example, the average operating expense per vehicle-hour in the United States declined 7 percent in real terms between 1986 and 1992 [American Public Transit Association (1993)]. Similarly, in a detailed study of Boston's public transit system Gómez-Ibáñez (1996) finds that real operating expenses per vehicle-hour increased rapidly in the 1970s but then declined in the 1980s after the state legislature strengthened management's position on key labor contract issues.

5.4 Rail versus Bus

A related issue is whether public transportation enterprises have been relying too heavily on rail rather than bus services as a means of attracting or retaining riders. In the United States, for example, rail is favored by the availability of federal capital grants at much more generous terms than operating grants. Since 1964, federal grants have been available to pay up to two-thirds (later 80 percent) of the cost of local transit capital improvement. Federal operating aid, by contrast, was made available only in 1974, is much less generously funded, and is distributed among cities on the basis of a formula rather than for specific projects.

The fear that capital grants might be distorting local choices was strengthened by the explosion of interest in rail transit projects among U.S. cities. Only one city (Cleveland) built and opened a new rail system between World War II and 1970. But in the next 25 years, twelve cities opened fourteen new rail systems while other cities expanded their older rail systems. Six of the new systems, built in relatively large metropolitan areas such as San Francisco, Washington, and Atlanta, use heavy rail technology, in which trains operate on a fully grade-separated right of way. Eight of the new systems use light rail technology, the modern version of a streetcar that draws power from an overhead wire so that trains can operate on city streets in mixed traffic; these were generally opened later and in smaller metropolitan areas such as San Diego, Portland, Buffalo, and Sacramento.

Just how high traffic densities have to be to justify rail transit has been a subject of intense debate since Meyer, Kain, and Wohl (1964) published an influential study of the comparative costs of bus, heavy rail, and auto in hypothetical or prototype corridors. They found that if one attempts to hold the quality of service roughly constant across modes, the comparison depends critically on peak corridor passenger volumes. At hourly volumes below 15,000, bus was generally cheaper while at volumes above 30,000, rail was cheaper; at intermediate volumes the comparison could go either way depending on local circumstances. Their results have generally been confirmed by a half dozen other researchers since; see Meyer and Gómez-Ibáñez (1981, p. 46) or Pickrell (1985b) for reviews.

As the new rail systems have opened, researchers have been able to analyze actual rather than hypothetical results. Among the more recent studies of this type, the most important is a comparison by Pickrell (1992) of forecast and actual performance of eight recently-opened systems, four heavy rail and four light rail. Ridership was far lower than forecast in the seven systems where such comparisons were possible: by 28 percent in Washington, D.C., and by more than 50 percent in all the others. In most cases about half of the ridership shortfall was due to failures to predict accurately various inputs to the forecast, such as downtown employment levels, gasoline prices, and transit fares. The balance of the shortfall appeared to be due to errors arising from "...the structure of the forecasting models, how they were employed, or the misinterpretation — or possibly misrepresentation — of their numerical outputs" [Pickrell (1985b, p. 164)]. Kain (1990) is less circumspect, as indicated by the title of his paper: "Deception in Dallas: Strategic Misrepresentation in Rail Transit Promotion and Evaluation."

Pickrell also found that costs were typically far higher than forecast. Capital-cost overruns, ranging from 17 to 150 percent, were found in all seven systems where comparisons were possible. About half was due to construction delays, the rest to underestimates of the real unit prices of inputs or the quantities of inputs required. Operating costs were also higher than forecast in five of the six cases where such comparisons were possible, in large measure because train speeds were slower than forecast.

Other researchers have examined the experience of individual metropolitan areas that built new rail systems or extensions, and argued that bus improvements would have been a less costly method of attracting or retaining ridership. Kain (1994, p. 16) estimates the demand for transit ridership using time series data for the Atlanta metropolitan area, for example, and uses that model to predict that between 1980 and 1993 Atlanta could have attracted 9 percent more ridership at only 37 percent of the cost if it had reduced fares and improved service on its bus system instead of building its new rail transit system. Using a similar approach, Gómez-Ibáñez (1996) finds that Boston's policy of extending its rail lines further into the suburbs adds $10.68

in new deficit spending per new ride attracted while a policy of reducing real fares on the existing system would add only $2.60 to the deficit for each new ride attracted.

Nor is there evidence that these costly rail systems have significant impacts on auto traffic. When the Bay Area Rapid Transit line opened between San Francisco and Oakland in 1973, 8,750 daily automobile trips on the parallel bridge were diverted; but soon after, 7,000 new automobile trips appeared on the bridge [Sherret (1975)]. Zurich's ambitious regional light rail system, which opened in 1990, has succeeded in substantially increasing transit usage, yet with no observable reduction in traffic flow at the city boundaries [OECD (1994), p. 97]. The reason is probably the "fundamental law" of traffic congestion, discussed earlier: new peak-period motorists soon take the place of those who switch to transit.

Less developed countries are facing a similar debate about the appropriate role of rail and bus transit, although in a context in which the vast majority of travelers are still using public rather than private transportation. Many major metropolitan areas in developing countries have built or planned new rail systems since the late 1960s, when Mexico City opened the first modern heavy rail transit system in the developing world.

A recent survey prepared for the Britain's Transport and Road Research Laboratory finds that developing nations have experienced many of the same ridership shortfalls and cost overruns as the United States [Halcrow Fox and Associates (1989), Fouracre et al. (1990)]. The study examined 21 large cities in developing countries with new rail systems: thirteen in full or partial operation and eight under construction or in advanced stages of planning. Of the thirteen operational systems, only three (Hong Kong, Porto Allegre, and Singapore) were built within 10 percent of their forecast capital costs while six had overruns of more than 50 percent. The most common reason for overruns was failure to accurately predict the difficulty of construction in a densely developed urban environment. Similarly, forecast ridership was approximately achieved in only two of the cities (Manila and Tunis) while in the remaining seven cases for which comparisons were possible actual ridership fell short of forecasts by 20 to 90 percent. Although the new rail lines are often heavily patronized by international standards — Mexico City has twice as many rail passengers as London, for example, — they still capture only 10 to 20 percent of all urban passenger trips, and the limited available data suggest no noticeable diversion from automobiles [Halcrow Fox and Associates (1989, p. 7.11)].

On the positive side, three of the ten cities with complete financial data indicated that fares covered operating costs and made some contribution toward depreciation. Furthermore, ten of the thirteen completed systems are estimated to have produced a social rate of return above 10 percent, in most cases due to large time savings by bus users who switched to rail. The largest social rates of return (above 15 percent) were in cities that had high rail patronage and relatively high values of time (Hong Kong and Singapore) or that had moderate patronage and very low construction costs (Cairo). The researchers did not compare the returns on rail investment with those that might have been achieved from improving bus systems.

5.5 *Privatization and Deregulation*

The growth in transit subsidies has encouraged some important experiments in the private provision of mass transit. The hope is that private operators, disciplined by competition, can reduce the costs of providing service and thus cut subsidy requirements. Furthermore, researchers have long pointed to select transit markets that can be served profitably [Viton (1980), Morlok and Viton (1985)]. These experiments have taken a variety of forms: with or without continuation of subsidy, and with or without regulation of entry and fares.

Much urban bus transit has long been privately provided without subsidy in many developing countries, sometimes even in competition with a publicly owned bus company that is subsidized. With a few exceptions, however, the government continues to regulate the routes the private operators serve and the fares they charge [Gómez-Ibáñez and Meyer (1993, pp. 22-36)].

Among the developed countries, private provision is usually accompanied by some subsidies, perhaps at reduced levels. The most common form of private provision is for public officials to contract with a private company to operate all or part of the system while fully specifying service characteristics and fares. The contract is awarded to the firm that bids the lowest subsidy to provide the service required. Often the existing public bus company is not privatized but competes against the private companies in the bidding. The London metropolitan area has had extensive experience with contracting out for bus routes beginning in 1985; the percentage of bus service competitively tendered in this way increased from 3 percent that year to 50 percent in 1993 [Kennedy (1995, p. 342)]. Contracting out has also been increasing slowly in the United States since the 1980s [Teal (1988), Gómez-Ibáñez and Meyer (1993, pp. 67-70)]. Sweden has encouraged local authorities to contract out for local bus service, especially after 1988 [Jansson and Wallin (1991)].

Studies suggest that contracting out can reduce costs by around 15 to 25 percent. In London, for example, Kennedy (1995, p. 343) estimates that over the years 1987 to 1992, tendered service cost 16 percent less to operate than comparable untendered services.

Furthermore, London Transport, the public bus company, is thought to have improved its efficiency significantly during this period in an effort to remain competitive and discourage further contracting out. Teal (1991) finds savings in the range of 25 to 30 percent among U.S. cities with contracted bus service. Less than a quarter of the savings came from lower wages, while the rest came from lower fringes, higher productivity, and reduced overhead expenses. Savings of 5 to 15 percent are reported in Sweden (Jansson and Wallin, 1991).

Outside London, Britain has experimented with the more radical step of simultaneously privatizing and deregulating local bus services while preserving the possibility of subsidy at local option. The British scheme, which went into effect in October 1986, involved three changes. First, controls on routes and fares were dropped so that a bus company, public or private, could offer virtually any unsubsidized service it liked (subject to providing advance notice and meeting safety requirements). Second, the large public bus companies that dominated the business in most metropolitan areas were set up as separate for-profit corporations and in many cases were eventually sold off to the private sector, often through labor or management buyouts. Finally, local authorities could supplement the unsubsidized service where they thought there was an unmet social need, but only by putting out the requested service to bid. National assistance for such subsidies was simultaneously cut drastically. Beginning in 1996, London is to be subject to similar measures.

The British reforms have been much studied because they represent the most ambitious effort at local transit privatization in developed countries to date — only New Zealand has adopted similar measures, starting in 1991 [Fielding and Johnston (1992)]. Results are still being assessed and debated; for two excellent summaries of the literature see White (1995) and Mackie *et al.* (1995).

The reforms were successful in one dimension: local bus service increased despite the subsidy cuts. During the first eight years of the reforms, the number of vehicle miles of service increased by 24 percent in all the deregulated areas and 21 percent in the major metropolitan areas, where the subsidy cuts were the harshest [White (1995, p. 71)]. As of fiscal year 1993/94, commercial (i.e. unsubsidized) service accounted for approximately 85 percent of mileage. The commercial mileage is more concentrated on high density routes and on the weekdays, however, so there are some times and places where there is less service than before, despite local government efforts to fill the gaps.

In addition, service innovations were stimulated by the bus operators' freedom to design their own commercial services. Particularly striking was the rapid growth in the use of minibuses with 16 to 25 seats. This development surprised some observers because it reversed a long-term industry trend to substitute capital for labor as real wages increased by, for example, eliminating conductors and increasing the size of the vehicle. Private operators found that the cost per seat-mile of operating a minibus was not much higher than that of a larger bus; the minibus is cheaper to maintain because it relies on a conventional truck rather than a purpose-built chassie. The minibus also can make more round trips per day since it stops less frequently for passengers and is more maneuverable. Use of minibuses often increased ridership per seat-mile, moreover, because they can operate more frequently and can penetrate housing developments with narrow streets.

The costs of providing a vehicle-mile of service declined substantially. Real operating costs per vehicle-mile declined by 41.7 percent in deregulated areas during the eight-year period. Only about one-sixth of the reduction was due to lower hourly wages, which fell about 12 percent; the balance was due largely to higher productivity, particularly among non-platform staff [White (1995, pp. 74-76)]. According to White and Turner (1990) about one-third of the cost savings per mile was due to the shift to minibuses.

Fares did not decline as expected, however, because all of the savings in cost per vehicle-mile were used to offset the subsidy cuts and to increase vehicle-mileage. In fact, real fares increased by 21.6 percent on average in all deregulated areas and by 44.4 percent in the large metropolitan areas, where the subsidy cuts were sharpest [White (1995, p. 78)]. In some areas, coordinated ticketing and travel passes were abandoned as competing bus companies declined to continue arrangements.

Even more discouraging was the substantial reduction in local bus ridership. Ridership fell by 27.4 percent in all deregulated areas and 35.5 percent in the metropolitan counties. Some decline in ridership would have been expected even in the absence of policy reforms, given that real incomes were rising in Britain. But the rate of ridership loss was greater than in the previous decade, reinforcing the supposition that riders may have been made worse off.

Many researchers have attempted to assess who won and lost from privatization and deregulation in Britain and whether, on the whole, social welfare was improved. The key difficulty is to isolate the effects of reforms from the effects of subsidy cuts and other adverse trends.

One approach is to use metropolitan London as a control. White (1990, 1995), Mackie et al (1995), and others have argued that the policy of gradually contracting out adopted in London proved to be superior to the more sudden and complete privatization and deregulation adopted in the rest of the country. As shown in Table 4, metropolitan London enjoyed as large a service increase and almost as large a unit cost saving as did the deregulated areas, but it suffered much smaller fare increases and losses of patronage.

Such comparisons are suggestive but far from conclusive given the difficulty in controlling for other differences between London and the rest of the country. In particular, government subsidies were cut far less in London, as shown in Table 5: seven years after deregulation London transit was still subsidized at 38.6 percent of fare receipts, whereas in the other metropolitan areas subsidies had been cut drastically to just 18.2 percent of receipts. Employment growth was stronger in downtown London than in the rest of Great Britain, moreover, and London was probably losing fewer bus riders to autos because driving and parking is so much more difficult and costly there.

An alternative approach is to compare the actual passenger decline with an estimate of the decline that might have been expected from the combination of exogenous trends and the service reductions and fare increases forced by subsidy cuts. Several researchers assume that the long term decline in bus ridership was 1.5 percent per year, for example, and then estimate the ridership losses attributable to reduced subsidies using standard rules of thumb about price and service elasticities. Others have built simple aggregate demand functions to try to estimate the counter-factual scenario [e.g., Mackie et al. (1995)]. The results appear to be sensitive to reasonable differences in assumptions about the exogenous trend and industry rules of thumb.

White (1990) argues that the ridership losses were greater than those one would expect from trends and subsidy cuts alone, so that deregulation and privatization must have worsened the industry's performance; Gómez-Ibáñez and Meyer (1993 pp. 55-58) come to the opposite conclusion.

The British experiment has also rekindled debate over whether competition is workable in urban buses. There has been only limited, but often intense, head-to-head competition — Tyson (1989) estimated, for example, that less than 10 percent of bus passengers have a choice of company. The incumbents have often driven off new entrants and there has been a wave of mergers among incumbents. Some British researchers blame residual regulation for the limited competition [Beesley (1990), Glaister (1993)], while others believe that competition is inhibited by the inherent advantages of incumbents, such as local knowledge, name recognition, and greater financial resources [Evans (1990, 1991), Mackie et. al.(1995)]. These incumbent advantages, however, do not appear more serious than those in many other industries where competition is thought to function reasonably well. An alternative explanation is that the network aspects of transit create economies of scale sufficient to make head-to-head competition overly expensive.

Indeed, where competition has broken out it has not necessarily been in the passengers' short-term interests. Competition has most often taken the form of matching or increasing frequencies on routes rather than cutting fares, apparently because passengers find waiting at a bus stop so inconvenient that they would rather take the first bus that arrives than wait for a bus from the company offering lower fares. Evans (1991), White (1995), and others argue that this results in wasteful duplication of services, uncoordinated schedules or, worse, buses scheduled slightly ahead of the competitor's so there is little effective reduction in passenger waiting times.

White (1990) believes that the large service increases after deregulation did not result in commensurate patronage gains because service competition was wasteful.

A few researchers, such as Dodgson et al. (1992), have begun using game theoretic models to better understand the nature of competition in this industry. Klein et al. (1996) point to the importance of defining the rights to public curb space that private operators are granted as a way of shaping the nature of service competition. How the overall system performs depends a lot on how smoothly operators mesh their products into an overall system. Whether this can be fostered through regulatory measures, through definition of property rights, or only through public coordination as argued by Nash (1988) is a question ripe for further research.

In sum, the British experience seems to have been neither the panacea that some hoped for nor the disaster that others predicted. Taxpayers clearly gained, and the impact of subsidy cuts on passengers was softened by the significant reduction in unit costs. Whether it would have been better to simply contract out, as in London, rather than take the added step of deregulating entry and fares is harder to tell. With contracting, passengers might not have suffered the risk of some wasteful forms of competition, but they also would not have enjoyed the benefits of service innovations.

5.6 Paratransit and Unconventional Services

The difficulties faced by conventional public transit systems have periodically provoked interest in paratransit and other unconventional forms of public transportation. Paratransit is often defined as a cross between taxi and conventional fixed route bus services. Paratransit is like a bus in that passengers not traveling together often share the same vehicle, but like a taxi in that the vehicle does not necessarily travel a fixed route or may deviate from its route or skip stops for the convenience of its passengers. Paratransit service is usually provided in vehicles smaller than a conventional bus, such as a minibus, a passenger van, or an ordinary sedan.

Paratransit services are quite common in the cities of the developing world, where they often carry more passengers than the conventional fixed-route bus systems [Shmakazi and Rahman (1995)]. Similar services were also found in U.S. cities in the first decades of this century but they all but disappeared due to a combination of restrictive regulation and competition from the private auto and conventional taxi and transit services.

Interest in paratransit revived in the 1970s as a potential answer to the problems that conventional transit faced in serving the dispersed trips of low density suburbs. The idea, christened "dial-a-ride" or "demand responsive transit", was to provide door-to-door service on request like a radio taxi. Vehicle productivity was to be higher than a taxi's, however, by using computer-assisted dispatching to schedule vehicles so that they served several different passengers simultaneously. Demonstrations conducted during the 1970s suggested, however, that the computer algorithms of the time were no better at matching trips than an experienced human dispatcher. Moreover, acceptable matches were less frequent than hoped for so that paratransit productivity and costs were usually no better than a taxi's [Meyer and Gomez-Ibanez (1981, pp. 73-76].

Paratransit services survived during the 1980s, but largely in the specialized role of carrying elderly and handicapped persons unable to use conventional buses or subways. Beginning in 1973, federal law required that public transit agencies receiving federal funds provide services accessible to the handicapped. Many agencies sought to do so by providing specialized paratransit in lift-equipped vans in lieu of more expensive efforts to fit out all their vehicles or stations for the handicapped. These paratransit services usually require reservations 24 hours or more in advance and often serve only limited destinations as well as a limited clientele. Despite these restrictions, moreover, costs are rarely as low as a conventional taxi's even allowing for the more expensive lift-equipped vehicles.

Two recent developments have encouraged transit planners to believe that there may be a wider role for paratransit services in developed countries. One is the near simultaneous appearance of minibus services after the bus deregulation in Britain and of private but illegal "gypsy" van services in competition with conventional buses in parts of New York City and Miami. The British minibuses probably shouldn't be classified as paratransit in that they seldom deviate from their route, unlike the New York and Miami van services. In both cases, however, high-frequency services in small vehicles have proven attractive to riders and profitable for operators. The fact that these services appeared only after deregulation or illegally also suggests that regulatory barriers may be very important impediments. Whether such services could be as effective or profitable in the typical American suburb is unclear, however.

The second hopeful development is improvements in computing and satellite-based automatic vehicle locating (AVL) systems. Low-cost scheduling software linked to geographic information systems are readily available [Stone, et al. (1993)]. Teal (1993) argues that with current technology we are now in a much better position to realize the promise of dial-a-ride than we were in the 1970s. Nelesson and Howe (1995) argue that instead of providing on-demand door-to-door service, as in the old dial-a-ride, it might be much less expensive and almost as convenient to provide on-demand service to a series of conveniently located telephone-equipped stops or nodes. The potential is still largely unproven but the time seems ripe for a new series of demonstrations.

5.7 Conclusion

Conventional public transportation remains an important component of any sizeable urban area. It is good at serving certain markets, particularly high-volume radial commuting flows, circulation in areas with many low-income people, and trips to areas with very scarce parking. Experiments with privatization demonstrate that many of these markets can be profitable and others can be served at reasonable cost with public subsidy.

Public transportation is not well suited, however, for low-density suburban service, especially in affluent areas. Nor can it be expected to alter land-use patterns sufficiently to create good transit markets where there otherwise are none. Many of the problems of public transportation arise because it is being asked to do to much. The result has often been out-of-control subsidies, inappropriate infrastructure decisions, and disappointment in performance.

Newer development everywhere is tending to take forms that do not produce good transit markets. This raises the question of whether newer forms of public transportation can evolve to serve some of these areas. While results to date are not very promising, the private-sector success with minibuses and vans and the popularity of taxicabs, even among the poor, provide hints at the possible ingredients for some successful new services. Research on ways to combine flexibility and real-time information to serve medium-density but dispersed trip patterns is likely to have a high payoff for the future.

6. Conclusion: Research Priorities

There are several areas in which additional research might shed light on key uncertainties that affect transportation policy. One such area is the potential costs of using land use policies to try to affect travel behavior. Interest in land-use policies continues despite evidence that they are unlikely to reverse the increasing dominance of automobile travel. In nations where the political system makes effective land-use control possible, the response may be to enact more restrictive policies. The research described in this chapter tell us something about the likely effects of land use controls on travel behavior, but we know almost nothing about the costs of such controls to household and firms. How are urban agglomeration economies affected by the different land-use patterns that could result from plausible policies?

Another area for research is accidents since accident costs appear to be a large component of the cost of driving. We do not know what portion of accident costs is external to the individual driver and therefore whether there is a strong case for corrective taxes or other forms of public intervention. Research is needed on how accident and injury rates depend on traffic volumes, on how people perceive variations in insurance costs, and on how people respond to applicable criminal and civil laws.

The valuation of both environmental damage and accidents requires knowledge of how people value changes in the risk of death. Despite considerable consensus about average values, little is known about how these values vary with age. Such knowledge is needed because some risks, such as air pollution, primarily affect the elderly while others, such as accidents, affect all age groups. There is also little empirical evidence on precisely how the concerns of families and friends are reflected in individuals' willingness to pay for risk reduction.

Another obvious area for research is on methods of providing public transportation suitable for today's dispersed land-use and travel patterns. So far the experience with paratransit is disappointing, but new technologies might dramatically change the picture. The ability to track vehicles, to gather information about traffic conditions, and to provide users real-time information offers potential improvements to existing types of paratransit and taxi services and may create entirely new market niches. Most research on such technologies has been oriented toward improving the quality of travel by automobile or conventional transit; comparable research on newer forms of transit would help determine their potential.

Finally, privatization and deregulation are currently in favor for both highway infrastructure and mass transit services. Just how well the private sector works in these contexts will depend on the nature of competition in very specific situations involving small numbers of competitors. We need to better understand how private construction firms compete for a franchise to build a highway, and how private bus operators compete for passengers on overlapping routes. An underlying goal would be to show how different rules of the game affect outcomes. By carefully specifying the conditions facing such firms, researchers using existing tools of industrial organization should obtain important insights.

Table 1.
Motor vehicle ownership and use, and extent of road network, selected nations: 1977-87.

	Four-wheeled motor vehicles in use (1000s)			Road network extent (1000s km)			Use intensity (1000s veh-km per km of road)		
	1977	1987	% change	1977	1987	% change	1977	1987	% change
USA	143,750.	179,044.	24.6	6,223.	6,233.	0.2	374.9	493.8	31.7
France	19,330.	26,195.	35.5	801.1	804.9	0.5	355.4	467.1	31.4
Spain	7,121.	12,083.	69.7	221.1	318.0	43.8	277.4	270.3	-2.6
Sweden	3,326.	3,626.	9.0	128.9	130.9	1.6	na	na	na
Hungary[a]	963.0	1,862.1	93.4	99.61	95.23	-4.4	145.5	231.2	58.9
Turkey	885.9	1,997.4	125.5	231.7	320.6	38.4	71.7	65.3	-8.9
Tunisia	188.8	442.5	134.4	21.89	27.37	25.0	106.1	182.5	72.0
Ethiopia	21.13	41.12	94.6	23.	38.99	69.5	na	na	na
New Zealand	1,446.	1,976.	36.7	92.62	93.11	0.5	na	na	na
Japan	32,044.	49,907.	55.8	1,088.	1,099.	1.0	314.6	499.4	58.7
Hong Kong	185.4	300.6	62.1	1.093	1.395	27.6	3,060.4	4,423.7	44.6
Brazil	7,433.	14,155.	90.4	1,502.	1,675.	11.5	na	na	na
Chile	480.5	938.4	95.3	74.90	79.22	5.8	88.7	183.2	106.5

[a] Use intensity is for 1976, 1986.

na: not available

Source: International Road Federation (1980, 1990), tables I, IV, V.

Table 2.
Per capita passenger car ownership, passenger travel, and road network:
United States and 17 European nations

	Registered passenger cars per capita	Registered passenger cars per km of road	Annual travel in passenger cars
U.S.A.[a]			(vehicle-km per capita)
1970	0.435	14.9	7,194.
1980	0.535	19.1	7,858.
1990	0.574	23.0	9,759.
% change 1970-80	23.0	28.2	9.2
% change 1980-90	7.3	20.4	24.2
Europe[b]			(passenger-km per capita)
1970	0.192	23.2	4,895.
1980	0.301	36.2	6,800.
1990	0.405	50.3	8,891.
% change 1970-80	56.8	56.0	38.9
% change 1980-90	34.5	39.0	30.8

[a] Source for population: U.S. Census Bureau (1994), Table 2. Source for other figures: U.S. Federal Highway Administration (various years): Tables MV-1, MV-201A, VM-1, and HM-10.

[b] Member nations of the European Conference of Ministers of Transport (ECMT): Belgium, Denmark, West Germany, Greece, France, Ireland, Italy, Luxembourg, Netherlands, UK, Spain, Portugal, Norway, Sweden, Switzerland, Austria, and Finland. For passenger travel, the figures exclude Greece, Ireland, Luxembourg, and UK includes only Great Britain (populations are adjusted accordingly). Source for population: United Nations, *Demographic Yearbook*, 1975, 1985 and 1992; plus Europa Publications, *The Europa World Year Book*, 1992, for Great Britain. Source for registered passenger cars: ECMT (1993), table 3-3-1, for 1970-80; Banister and Berechman (1993), p. 16, for 1990. (Banister and Berechman's data are from the same source but contain more recent years.) Source for km of road: ECMT (1993), table 3-2-1; 1989 data is used for 1990. Source for passenger travel: ECMT (1995), p. 30.

Table 3.
Average motor fuel tax rates: United States

Year	Nominal rate (cents/gal)			Real rate, 1992 prices (cents/gal)	Effective real rate, 1992 prices (cents/veh-mi)
	Federal[a]	State[b]	Total		
1960	4.0	5.9	9.9	46.9	3.28
1970	4.0	7.0	11.0	39.8	2.94
1975	4.0	7.7	11.7	30.5	2.26
1980	4.0	8.3	12.3	20.9	1.35
1985	9.88	11.3	21.2	27.6	1.52
1990	10.50	15.2	25.7	27.6	1.31
1992	15.06	16.8	31.9	31.9	1.48

[a] Source: U.S. FHWA (1992), table FE-101. For 1985 and later, rate shown is a weighted average of different rates applied to gasoline and diesel fuel. The weights are aggregate fuel consumption, from U.S. FHWA (1990, 1992), table MF-2; and U.S. FHWA, *Highway Statistics, Summary to 1985* (Washington, D.C.: U.S. Government Printing Office, 1987), p. 9, table MF-221. For 1990, during which the tax rate went up in December, the rate shown is the average by month, i.e. it is 11/12 times the initial rate plus 1/12 times the final rate.

[b] State gasoline and diesel tax revenues [AAMA (1993), p. 78] divided by motor vehicle fuel consumed [AAMA (1993), p. 64].

[c] Previous column divided by the consumer price index relative to that for 1992. Price index is from U.S. Census Bureau (1994), table 747.

[d] Previous column divided by fleet average fuel efficiency in miles per gallon for cars, from U.S. Census Bureau (1994, table 1024) and (1981, table 1092) (the latter used for 1960 only).

Table 4.
Percentage changes in local bus service characteristics:
Great Britain, 1985/86 to 1993/94

	Deregulated areas		London
	All areas	Metropolitan areas	
Vehicle miles of service	+24.0	+20.6	+24.0
Real cost per vehicle-mile	-41.9	-45.5	-35.1
Real average fare	+21.6	+44.4	+6.7
Passenger trips	-27.4	-35.5	-3.0

Source: White (1995)

Table 5.
Government revenue support for local bus service: Great Britain

	Deregulated areas		London
	All areas	Metropolitan Areas	
1985/86:			
Revenue support	510	319	207
Passenger receipts	1,944	640	426
Support as percent of receipts	26.2%	49.8%	48.5%
1992/93:			
Revenue support	237	114	167
Passenger receipts	1,725	626	432
Support as percent of receipts	13.7%	18.2%	38.6%

Note: Figures are in millions of British pounds at constant 1992/93 prices.
Source: U.K. Department of Transport (1993)

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