AUTOMOBILE SUBSIDIES, LAND USE, AND TRANSPORTATION POLICY

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ABSTRACT

Automobile use in the United States has been extensively subsidized through highway funding policies and indirectly through externalities and petroleum subsidies. A consequence of these long-term subsidies is urban and regional land use characterized by extensive and increasing sprawl. An estimate of these subsidies is established based in part on the detailed reporting requirements under Wisconsin's transportation aid formula and on existing literature. Long established urban land theory is used to link subsidies to land use. The use of registration fees and gasoline taxes are considered as potential policy responses.
Urban land use development in the 20th century has been characterized by increasing dispersal or sprawl. In older, established urban areas this has occurred in the form of low density development at the urban fringe and scattered development beyond. In newer cities, increasing dispersal occurs in the form of relatively low density urban centers, even lower density development emanating from these centers, and scattered development beyond the urban edge. This characterization applies not only to the U.S., but to a considerable degree to other industrialized as well as developing counties (Weaver 1987; Rodriguez-Bachiller 1986; Cherunilam 1984).

Critics of this pattern have argued that sprawled development is undesirable because of higher costs of infrastructure, particularly highways; higher costs of public services; higher levels of energy use and air pollution related to increased travel requirements; noise; safety; and visual and functional disruption of communities (Real Estate Research Corporation 1974; Wachs 1981). Other undesirable features are conversion of prime agricultural and environmentally significant lands, the isolation of non-driving poor, old, young, and handicapped, and the erosion of current or potential tax base in existing urban centers (Hall 1976; Wachs 1977). There is general agreement that present patterns have evolved from market forces as modified by land use planning, and that evolving land use reflects consumer desires operating within this market (Weaver
Essential elements in the evolution of dispersed land use patterns has been the emergence of the automobile (including functionally similar vehicles such as vans, pickup trucks, and four wheel drive recreational vehicles) as the dominant mode of personal transportation and the provision of highway infrastructure to accommodate automobile travel. A motorized means of personal travel is necessarily the dominant transportation technology to serve highly dispersed trip origins and destinations.

In this article, I consider the magnitude of automobile subsidies and their significance for land use and transportation policy. The central argument is that the transportation system, based on and designed largely for the automobile, has been systematically subsidized in the United States with the result being a settlement pattern with a greater level of dispersal than would have otherwise evolved.

That automobiles are subsidized and that this will affect land use are not new ideas. This is an old argument. A surprising omission in the literature, however, is the lack of systematic, empirical treatment of the subsidies and their impact on urban form. In fact, there appears to be a widely held myth, even among some transportation professionals, that highway users pay for all the direct capital and operating costs of highways through user fees such as fuel taxes and registration fees. Pucher (1988:p. 515) in discussing roadway subsidies implicitly
recognizes this myth:

"One might argue that user charges in the United States have financed the costs of highways and that motorists as a whole have not been subsidized. It is true that user charges cover most of the government expenditures on roadways, but not all."

He goes on, however, to cite recent work at the U.S. Department of Transportation (Lee 1987) which reports that user fees and earmarked taxes at all government levels provide only $36 billion or 69% of the $52 billion of highway expenditures in 1985. As will be shown below, even these data appear to considerably underestimate the subsidies.

The research on transportation subsidies has been diverse, but generally segmented, often focusing on specific, complex, difficult to measure subsidies. Many of these subsidies derive from the public good nature of the transportation system and the common property resources which the system uses, such as urban air quality. Subsidies associated with congestion are treated by McConell and Straszheim (1982), Roth (1967), and Weaver (1987); peak hour auto users by Altshuler (1969); parking by Wachs (1981); and air pollution and other indirect automobile related costs by Grad et. al. (1975) and Wachs (1977,1981). Crandall et. al. (1986) have considered the costs and benefits of U.S. air pollution regulations as part of a broader economic treatment of automobile regulation. A related area of the literature on transportation subsidies has focused on transit financing and the
growing subsidies that have become necessary to maintain mass transit in the U.S. and Europe, for example see Hirten (1973), Vickery (1980), Vuchic (1984), Wachs (1981), and Weaver (1987).

By focusing on particular areas of automobile subsidies, on public transit subsidies, and on cross subsidies between users and/or modes, two areas of research have been relatively neglected. First, there has been little empirical work to estimate the overall level of subsidies to transportation within urban agglomerations and larger regions, beyond the data on highway receipts and expenditures reported by the U.S. Department of Transportation's Transportation Systems Center (Lee 1987) and the Federal Highway Administration (1987). Second, the empirical relationships between aggregate transportation subsidies and consequent urban and regional form have been neglected despite a long and rich theoretical literature and considerable empirical literature on specific subsidies.

Because the subsidies for public mass transit have been extensively treated, I will focus on automobile subsidies in aggregate including direct highway subsidies. These direct highway subsidies are for the construction, maintenance, and operation of highways that are not funded by user fees. The findings on direct highway subsidies, along with what is reported in the literature on indirect automobile subsidies, will be used to provide an empirical approximation of aggregate automobile subsidies. The indirect subsidies include: air pollution and related aesthetic losses, water pollution, losses to society from
human injuries, and opportunity cost of land used for the highway system. These costs or externalities are those which have not been internalized and therefore are imposed by automobile users on others, including other automobile users. Pucher (1988: p 515) in discussing these costs states:

"Society as a whole has had to bear the social and environmental costs, which economists describe as "external costs." The failure of public policy to internalize these costs through surcharges on automobile use means that roadway construction and auto use have been implicitly subsidized by the amount of underpricing—in addition to providing direct subsidies by reported expenditures."

No attempt is made to estimate the subsidies involved in a number of other externalities that have been identified in the literature such as noise, community disruption, increased school busing costs, social deprivation, and aesthetic losses beyond those associated with air pollution. For the subsidies that are discussed, the approximations of subsidies, although inexact, provide some insight on the magnitude and consequences of the aggregate subsidies on urban form.

The linkage of urban form to aggregate subsidies is based on the fundamental relationship between transportation technology, costs, and the patterns of land use in terms of land value, population density, and particular land uses. Transportation costs are the costs of movement to individuals in time and out of
pocket costs. What these costs are and how they affect behavior and subsequent land use can not be fully understood without considering the mix of modes that make up the transportation and telecommunications system in a particular urban agglomeration and its surrounding rural areas, the costs of using various modes, and the subsidies which make the costs appear less than they are to the system user.

The existence of substantial subsidies to automobile users has major policy implications in two respects. First, if these subsidies are deemed inappropriate public policy, it implies that the funding of roads under the jurisdiction of local governments be moved from local general purpose revenues to user fees. For many local units of government in the U.S. this would entail eliminating local highway costs from the property and/or local sales tax and imposing a user fee such as a higher gasoline tax or a local automobile registration tax---what is popularly called a "wheel tax." User fees would be used to fund the local share of local road costs, recognizing that state and federal transportation revenues from user fees already supplement local highway expenditures. A more drastic policy would be to internalize external costs as well by funding all costs, i.e. direct and indirect, with user fees. While in keeping with traditional economic prescription, this would revolutionize transportation policy.

The second major policy implication is that if the funding of local highway costs is not to be based on user fees, then the
funding for alternative modes such as mass transit, walkways, and bikeways should be reconsidered. When transit subsidies are being considered in budget debates at the federal, state, and local level, recognition is rarely given to the subsidies afforded automobile users. The underlying assumption is that automobile users pay their own way and the community can only go so far in providing public services. An argument can be made that transportation modes can compete only if a level playing field exists, i.e. equal subsidies prevail across modes. However, choosing to heavily subsidize all transportation modes can not be considered a recipe for an efficient transportation network. At a minimum, however, clearer recognition of automobile subsidies might well change the nature of the dialogue on transportation policy and funding. With this recognition may also come the realization that long term automobile subsidies have resulted in the over-use and over-provision of highways. This in turn has resulted in excess dispersal of land use and the inability of public transit, walking, and bicycling to carry a significant portion of travel in many areas (Newman and Kenworthy 1989).

The next section of the paper briefly summarizes the relevant portions of long established urban spatial theory as developed by Wingo (1961), Alonso (1960 and 1964), Kain (1962), and Muth (1961) to describe the consequences of reducing transportation costs. The third section delineates direct automobile subsidies in the form of expenditures by local govern-
ments on local roads using U.S. and Wisconsin data. The fourth section uses literature on national data and detailed data on a middle-sized city of 176,000 population to estimate approximate indirect subsidies or externalities at a community level. The final section of the paper addresses the policy implications of the findings on automobile subsidies and discusses policy options.

I. TRANSPORTATION AND LAND USE PATTERNS

Lowdon Wingo in the introduction to his book, *Transportation and Urban Land*, states that the National Interstate and Defense Highway Act of 1955 brought to an end an era in planning (Wingo 1964). He argues that the Highway Act released:

"the tremendous forces for urban reorganization previously held in check by the restraining bonds of existing opportunities for transportation and communication... Then there are vast, if invisible, changes which new facilities have induced in the processes of urban organization -- new prime land made accessible for development, the older areas more acutely disadvantaged, the competitive opportunities redistributed" (Wingo 1964: p. 1-2).

While Wingo's central theoretical statement remains intact, the evolution of land use, and urban and regional planning has been considerably more gradual. The impact of the Interstate and Defense Highway Act on land use cannot be disputed and should not
be underrated. In actuality, however, the construction of the Interstate Highway System is only one episode in a much longer and larger process which has seen the ongoing release of the bonds of existing transportation and communication infrastructure. The process was evident with the advent of the streetcar in the 1880's and continued with the development of roads. The system of freeways and expressways has been expanding in the United States since the end of the World War II. The Interstate Highway System was a continuation and for a time an acceleration of highway development. The impetus of the Interstate program has now passed. Highway development, however, continues as does the continuing process of urban reorganization.

Following the work of Wingo (1964) and other theorists the travel cost consequences of increasing transportation infrastructure within an urban area can be represented graphically by Figures 1 and 2. In Figure 1, an initial state of transportation infrastructure has a transportation cost function labelled A. This infrastructure is related to unit rent and population density functions Ar and Ad in Figure 2. Increasing infrastructure, for example adding travel lanes or improving a roadway from an arterial to freeway configuration will reduce, all other things are equal, travel time and out of pocket costs. The new reduced transportation cost function is shown as B in Figure 1. Individuals--making work trips in Wingo's model--will respond by changing residential location decisions. Unit rents and densities respond to the changed cost function with
relatively lower population densities and unit rents near the urban center, increased densities and rents beyond a certain point e, and with the edge of settlement extending from ma to mb. The new rent and density functions are denoted as Br and Bd.

Highways and other transportation infrastructure are public goods and much of the revenue for providing local infrastructure is not provided by user fees. Hence, cost functions A and B are lower or are perceived to be lower for users than they would otherwise be. In addition, for roadways, as with other public goods, there is a strong tendency to overuse them in the absence of some rationing mechanism. Overuse results in congestion which precipitates improvements such as improved signalization, added lanes, and new roads. These improvements are justified in part by cost-benefit analyses which focus on travel time, accident reductions, and construction costs, but ignore the consequences of the urban reorganization and the associated increased travel with both user and external costs. The projected benefits of current and projected travel levels are rarely corrected to reflect the undercharging of travel. This has the effect of exaggerating the benefits of congestion relief (Weaver 1987).

The result is the over-provision of transportation infrastructure relative to what it would be if user fees could be imposed to capture more or all of the entire direct cost--not to mention externalities--of transportation infrastructure use. Graphically, this can be shown in Figures 1 and 2 by considering functions B, Br, and Bd as representing the current, subsidized
situation. Shifting more costs to users would result with a higher cost function \( A \), and all other things equal, steeper unit rent and population density functions \( Ar \) and \( Ad \). The outcome of placing more of the costs of automobile use on the user would be less sprawl and higher density development.

To carry this analysis to its logical conclusion, consider the consequences of continuing to decrease travel costs such that the cost function in Figure 1 approaches a horizontal position. The unit rent and population density functions also approach a horizontal position. In other words, if transportation costs become low enough, there is little advantage to being near an urban center, or within a multinucleated situation with a diverse set of trip destinations, being near any center. Other factors in the location decision become increasingly important and proximity to one or more centers becomes a trivial concern because all locations provide good access. In terms of land use, sprawl and contiguous urban growth are logical outcomes. The glue holding the compact city together has been lost.

The consequences of this ungluing has been recently described by Blackley and Follain (1987), Cervero (1987), Leinberger and Lockwood (1986), and McMillen (1989) for residential, commercial, and manufacturing location choice. Many manufacturers are leaving old centers for locations that sometimes have no center at all, simply access to the Interstate System and other high capacity corridors. In cases where regional population is large, for example New Jersey and Southern
California, development is contiguous and congestion widespread. Firms and individuals appear to be adjusting to the decline of old centers, however, by adjusting locations to new centers or other more peripheral locations so as to hold travel time constant (Gordon et. al. 1987). In areas with more open land available, such as southern Wisconsin, discontiguous growth as well as dispersed centers are evident.

Sprawl can not be attributed to automobile subsidies alone. Clearly, the evolution of technology in travel, personal preferences for suburban and rural residential location (Hanson and Jacobs 1989), U.S. policies to subsidize home ownership and single family housing (Pucher 1988), and telecommunications (Nilles et. al. 1977) have played large roles in providing for the ungluing. However, extensive automobile subsidies over many decades suggest greater dispersion in land use than would otherwise be the case.

II. LOCAL GOVERNMENT EXPENDITURES ON ROADS AND STREETS

State highway policy is typically viewed from the perspective of the state agency overseeing the highway system. There is the presumption that highways are funded by user fees, primarily motor fuel taxes and registration fees. This is certainly the case in Wisconsin.

In reality, all units of government in Wisconsin spend approximately $1.4 billion per year on roads and streets, of which only one-half is funded by state and federal user fees.
The other half is paid for with local revenues of which the local property tax is the most important source. Wisconsin Department of Transportation (WDOT) and local government highway expenditures for the years 1978-1985 are compared in Figure 3. WDOT data (WDOT 1985) are for highway and bridge expenditures from state and federal sources. Included in these WDOT totals are aids to local units of government for roads, streets, connecting highways and bridges.

Local government expenditures in Figure 3 include all transportation related expenditures reported on Municipal Finance Reports submitted to the Wisconsin Department of Revenue. This time series data is unique in it's level of detail and completeness. The reporting provisions state that "all road and street construction and maintenance expenditures within the right-of-way are generally reportable as eligible cost items" (Ammerman and Novak 1989). The eligible costs are divided into three major categories: 1) maintenance, which includes maintenance of pavements, bridges, culverts, storm sewers, and traffic control devices, and snow plowing; 2) construction, which includes right-of-way acquisition, engineering, signing, and construction costs for pavement, bridges, culverts, and storm sewers; and 3) other highway related costs which include machinery and vehicle costs, buildings, debt service payments, traffic police, and street lighting. The local government expenditures shown in Figure 3 are net of WDOT aids, which as noted above, are shown under WDOT expenditures.
Local government expenditures and state and federal user fee based expenditures in Wisconsin are approximately equal and slowly growing in constant dollars as shown in Figure 3. The 50/50 ratio of fee based expenditures to local government general revenue expenditures is markedly different from the 70/30 ratio finding by Lee (1987). This difference is at least partially explained by the more inclusive reporting requirements in Wisconsin.

The heavy reliance of highways in Wisconsin on local government expenditures is related to the proportion of highways under local government jurisdiction, 88% (Ammerman and Novak 1989), and the small proportion of the costs of those roads which are funded by WDOT aids, approximately 25% as shown in Table 1. The aid levels range from a low of 18% of reported costs for incorporated areas under 10,000 population to a high of 36% for towns.

This level of funding reflects a policy which is to provide state aids at varying levels for roads and streets under the jurisdiction of local units of government according to three functional classifications: 1) arterials, representing 2.6% of streets and roads under local jurisdiction, 2) collectors, representing 20%, and 3) local roads, representing the remaining 77%. The level of support under existing policy is to provide funding via WDOT for approximately 40% of the cost of arterials, 28% of the cost of collectors, and 15% of the cost of local roads (Governor's Special Committee on Transportation Aids 1982).
The differences in these funding levels is due to the assumption of greater financial responsibility by the State for roads serving primarily a travel mobility function relative to roads primarily serving a property access function. The relative functions and benefits of these road classifications are important for policy. While property access is essential, the standards to which the network of arterials, collectors, and local roads are built, are designed to provide high levels of mobility, primarily for the automobile. It is questionable whether three fourths of the direct cost of roads and streets under the jurisdiction of local units of government in Wisconsin should be funded by local government general revenues.

The 1988-89 biennial budget for the State of Wisconsin has made the allocation of local aids according to functional classification a moot point by providing local aids at a flat 24% of local highway costs regardless of classification. The overall level of support, however, is based on historical classifications of roadway (arterials, collectors, and local) and the level of state support for each of these types.

To understand the significance of transportation expenditures by local units of governments, it is useful to consider expenditures and property taxes—the primary source of local revenues—for varying sizes of communities in Wisconsin; Milwaukee (population 608,000), Madison (population 176,000), and selected towns representing a range of urban edge to rural conditions. Highway expenditures and property tax levies for
1987 are shown in Table 2.

In Milwaukee, gross reported highway expenditures amounted to $107 million in 1987. After adjustment for general state highway aids of $26 million, this left $81 million, or $133 per capita, as the local burden. The $133 per capita local cost for highways does not include the payment of county taxes included in "other tax levy" in Table 2, of which $27 per capita (using a statewide average) funds county highways. $81 million is a significant outlay, representing 21% of the net property tax burden of $382 million. Compared to the local tax levy (the tax levy for operating local government), the local burden of highway costs is very substantial, representing 59% of the local levy.

The local costs of highways in Madison were $18.5 million of which $4.4 million is supported by user fees in the form of state highway aids. This leaves a local share of $14 million, representing 10% of the net property tax and 31% of the local tax levy. The local burden of highway costs was $80 per capita, somewhat lower than Milwaukee. Again, this does not include the $27 per capita local share of the cost of county highways. For comparison to transit costs, the Madison subsidy of the transit system and elderly/handicapped transit was $22 per capita.

Based on aggregate statewide data as well as detailed analysis of four towns shown in Table 2, the local costs of highways in towns in Wisconsin are generally similar in magnitude to Milwaukee and Madison per capita costs. The per capita costs in the rapidly growing, relatively affluent Town of
Middleton on the Madison urban fringe are markedly lower reflecting considerable recent population growth without the need to date to expand roadway capacity.

The implications of highway costs for local budgets are complicated by the great diversity of town characteristics and the revenue sharing provisions in the state tax credits. In the Town of Middleton and the rural towns of Primrose and Vermont (all Dane County), net highway expenditures are about equal to the local tax levy. Net highway expenditures in the northern Wisconsin town of Hubbard (Price County) are much larger than the local tax levy. This is explained by the hold harmless provisions in the transportation aids formula, the use of the previous six years of costs in determining aids noting that current cost are high relative to previous years, and revenue sharing provisions in the state tax credits to help poor areas.

In summary, these data demonstrate that across rural and urban areas, there is considerable subsidy provided to highway users. While the same streets are used for buses, trucks, and other commercial vehicles, usage is overwhelmingly by automobiles and other personal vehicles. Aggregate data for Wisconsin reveal very large ongoing subsidies equivalent to what users are paying through user fees. This detailed picture for Wisconsin appears to be roughly representative for other states, noting the U.S. Department of Transportation findings (Lee 1987) and comparison of Wisconsin local highway aid levels to aid levels in other states (Governor's Special Committee on Transportation Aids
1982b). In the comparison, Wisconsin was near the national average for the percentage of state highway user revenues shared with local government and for the amount of aid per local road mile.

III. INDIRECT SUBSIDIES

Although the direct subsidies described above are substantial, the indirect subsidies associated with externalities and petroleum subsidies are potentially larger. Their magnitude is highly uncertain and methodologies to estimate them controversial. My purpose here is to provide an order of magnitude conjecture based on what is known or can be inferred from the literature about these subsidies. The estimate of indirect subsidies will be combined with the direct subsidies discussed above to provide an aggregate subsidy estimate.

Because of the focus of subsidies on urban, and to some extent, regional form and because the levels and types of externalities are regionally specific, the approach taken is to consider the indirect subsidies for a mid-sized city, Madison, Wisconsin. The general findings from this case study, however, can be generalized to other cities. Due to data availability, the indirect subsidies will be estimated on an annualized basis for the year 1983.

The externalities that are treated are air pollution including aesthetic losses, water pollution related to road salt use, personal injury and lost earnings associated with accidents,
and land use opportunity costs for land removed from other uses. Petroleum subsidies are also considered. Externalities which are excluded due to lack of research on aggregate nationwide cost include community disruption due to physical barriers, noise, etc.; the costs associated with urban reorganization, to use Wingo's terminology; larger regional and global impacts attributable in part to the automobile such as acid deposition from nitrogen oxide emissions, and the greenhouse effect from carbon dioxide emissions; and private parking subsidies, noting that the bulk of parking occurs on public roads and facilities, included in the state level data discussed above.

Air Pollution

The air pollution impacts of the transportation system, and automobiles in particular, have been studied and are the subject of a major, ongoing regulatory program to reduce them under the auspices of the Clean Air Act. Seskin (1978) in his treatment of automobile air pollution policy cites two primary estimates of the damages due to air pollution from mobile sources. The first, prepared for the Office of Science and Technology (1972) provided an estimate of benefits for the decade 1976-1985 and then for 1986. The estimated annual benefits ranged from $3.5 to $9.1 billion in 1972 dollars. This study, however, assumed that vehicles would be "zero-polluting" while it is more likely that something on the order of half of the emissions and damages would be remaining. This implies to an annual damage level in 1986 of $1.8 to $4.6 billion which in 1983 dollars is $4.3 to $11
billion.

The second study cited by Seskin is by the National Academy of Sciences (1974) which arrived at an estimate of total benefits from reducing mobile-source emissions of $5 billion, or $10 billion in 1983 dollars. Since this represents benefits from reducing emissions, it is difficult to translate this into damages from the air pollution remaining. Assuming that only half of the emissions are controlled and that damages are directly proportional to emissions (an unlikely assumption), remaining damages would be $10 billion.

Crandall et. al. (1986) and Freeman (1982) report estimates of total damages that in aggregate are in the same range. In their analyses, however, aethetics are a significant part of the damage and automobile air pollution controls to date are not found to have reduced the damages to a very large degree. Crandall et. al. relying extensively on Freeman's findings conclude that the total value of the elimination of man-made smog through automobile emissions would total $7.9 billion in 1983 dollars.

Recent work on the effects of lead poisoning suggest that neurological damage to children from lead additives in gasoline is a far more serious issue than previously believed. Because of the aggressive stance by EPA on removing lead additives, however, further damage due to new emissions are rapidly being eliminated and for that reason are ignored here.

Attempting to assign uncertain damages to a given city is
further complicated by the disparity between urban areas in damage incurred. At one extreme, a unit of emissions resulting in air pollution in the Los Angeles area is far more damaging than a unit of emissions in a small, isolated town in the great plains. A simple assumption is to take the average damage level per capita and apply it to Madison, recognizing that for this particular case it probably represents an overstatement.

For the purposes of an approximate estimate, a national damage figure of $7 billion in 1983 dollars was assumed and a national mean for the damage was used, resulting in a damage figure for Madison of $5.2 million as shown in Table 3.

**Personal Injury**

The ubiquitous use of the automobile and the nature of the technology lead to formidable negative impacts on people and property in addition to air pollution health effects. These are the result of accident related injuries, fatalities, and property damage to vehicles, transportation infrastructure, and other property. In order to assess the subsidy involved, it is necessary to separate those costs which are internalized to the automobile user and those costs which are born by society.

Because a substantial portion of property damage is insured by automobile users via insurance coverage and, to a lesser degree, by direct payments, those costs are largely internalized and not accounted for here. This leaves the costs of personal injury and lost earnings.

Although individual health insurance is widely held, the
medical costs of automobile accidents can be viewed as a loss to society and an implicit subsidy because health insurance does not distinguish among causes of injuries and disease or the amount of automobile travel. Automobile accidents are a major source of medical costs, with the effect that these costs, which are substantial for society, are included within overall health insurance premiums. If the medical costs for automobile accidents were separately insured, insurance rates for remaining causes would be lower.

In the case of Madison, there were 1628 accidents in 1982 with an average personal injury cost per accident of $7700 for a total value of $12.5 million (Wisconsin Department of Transportation 1983). Associated with these accidents are losses to society from lost labor which amounted to $1.6 million. These values are included in Table 3. As no value is assigned for fatalities, this estimate is very conservative.

**Land Opportunity Cost**

The third subsidy is the cost of land placed under blacktop which could have been used for some other purpose. Because roads do provide access which is essential in giving value to land, a subsidy in the form of an opportunity cost occurs if more than a necessary or "optimal" amount of land is dedicated to highways.

It has been reported that worldwide, at least a third of a city's land is devoted to roads, parking lots, and other motor vehicle infrastructure. In U.S. cities, close to half of all urban area goes to accommodating the automobile, while in Los
Angeles the figure reaches two-thirds (Renner 1988). Because the density of roads increases in urban areas, and within urban areas in their central portion where the land is most valuable, the opportunity cost of land use is potentially enormous. This cost exists when it is possible to reorganize transportation, other infrastructure, and land use to provide equivalent access with less land area devoted to highways. Cevero (1989) notes that local streets have considerable unused capacity in that they provide 80% of the lane miles of roadway nationally while carrying only 15% of vehicle mileage.

To address the land opportunity cost issue for Madison, the area of Madison under highways (public and private parking facilities are ignored) was estimated. Using an assumption that one-third of that area is not essential or would not be essential if land use and transportation infrastructure were reorganized, the value of that land and the loss of tax revenues to the city are estimated.

As of 1985, Madison had 557 miles of roadway of which there were 62 miles of principal arterials, 76 miles of minor arterials, 57 miles of collectors, and 361 miles of local streets. Using conservative, weighted estimates of mean roadway width for each of these categories results in an estimated 2570 acres of highway. This amounts to approximately 11% of the developed, taxable land area of Madison, noting that Madison has considerable area allocated to parks, government, and some undeveloped land.
Based on existing property tax rates, the increased revenues to the city if the area of roadway were reduced one-third would be $1.0 million in 1983 dollars as shown in Table 3. The actual value of that land is considerably greater, in excess of $50 million at current land values. For purposes of this paper, the foregone property tax revenues is used as a conservative estimate of the opportunity costs. While it might be argued that making the added land available would simply mean that the same amount of economic activity would be spread over more land, this argument only holds for cities with land available for development within their borders and then only for the short run.

Environmental Damage from Road Salt

As understanding of wet and dry deposition has improved in recent years, air emissions from mobile sources are increasingly recognized as sources of water pollution and acid rain. Because of a paucity of estimates in the literature, these important, but unquantified externalities are ignored in this paper. There is a body of research on water pollution from road salt for snow and ice removal.

A study by Murray and Ernst (1976) identified $2.7 billion in damages, which in 1983 dollars would amount to $4.7 billion. Over 90% of the damage, however, was attributed to vehicles and highway structures, while $350 million in 1983 dollars was damage to water supplies, health, and vegetation. Since the cost to vehicles is already born by the user, and highway costs having
been treated previously, only the remaining costs are considered.

As in other external costs, a simple average is used to estimate the cost imposed by Madison drivers. Assuming 100 million population in the snow belt "salt zone", Madison's share of the damages based on population is about $600,000 per year.

**Petroleum Subsidies**

The petroleum industry receives depletion allowances and other tax breaks which are estimated to total over $20 billion in 1984 (Hines 1988: p. 28). Based on gasoline consumption for personal travel in Madison (Dane County Regional Planning Commission 1983), this subsidy amounted to $1.8 million in 1983 as noted in Table 3.

**Aggregate Direct and Indirect Costs**

Total direct and indirect annual automobile subsidies for Madison are summarized in Tables 3 and 4. The indirect costs identified total $23 million per year, about twice the level of the direct subsidies at $11.7 million. Because of the uncertainty of these values and the inclusion of some costs attributable to trucks, the range of indirect costs could easily be from 50% lower to at least 100% higher. Both direct and indirect subsidies vary considerably on a per capita basis across cities and regions. The total $34 million subsidy is equivalent in 1987 dollars reported in Table 4 to $257 per year per capita, $412 per motor vehicle and $564 per dwelling unit. Pro rated to gasoline sales, the subsidy is equivalent to $1.27 per gallon in 1987 dollars, with $.53 of that for direct highway costs.
IV. POLICY IMPLICATIONS

Cities and regions in the U.S. have become heavily dependent on the automobile to meet almost all local transportation needs. The nature of land use patterns is such that there is little choice as to the mode of travel—walking, mass transit, and biking are not viable options for most travel. With these land use and travel patterns, come air pollution, noise, costs of maintenance, a heavy use of and dependence on petroleum, congestion, and perhaps most importantly, little flexibility to address these problems. Land use decisions are long term decisions.

In a recent study, Newman and Kenworthy (1989) found that "physical planning policies, particularly reurbanization and a reorientation of transportation priorities" are important means of reducing automobile dependence. In their work using international data, half of the wide variation in gasoline use between cities was explained by economic and technological factors such as gasoline price, income, and vehicle efficiency. The other half of the variation they attributed to physical factors. Because of the importance of the physical factors, Newman and Kenworthy identify a set of policies for physical factors which planners can control to reduce automobile dependence:

* increasing urban density
* strengthening the city center
* extending the proportion of the city that has inner-area
land use

* providing a good transit option
* restraining the provision of automobile infrastructure

For physical planning policies to have much promise for reducing sprawl and dependence on private motor vehicles, it is necessary that such policies be supported by and coordinated with economic policies in land use, housing, and the provision of infrastructure including highways. Subsidies for automobiles and housing which favor low density suburban development (Pucher 1988) create overwhelming barriers to the establishment and effectiveness of countervailing physical planning policies. Cervero (1989:p. 148) notes that:

"Western Europe stands as a testament to the effects of higher transportation costs on land use...It is no coincidence that European nations that exact high fuel taxes from motorists also have a balanced job and housing growth, limited sprawl, and heavily patronized transit services."

The automobile subsidies identified and their effect on travel and land use suggest two directions for policy. The first direction is to eliminate the subsidies while the second is to reconsider funding of alternative modes. The purpose of the former policy is to inform individual travel and location choices and raise the visibility of public decisions on transportation infrastructure and land use. In the long run, this will alter the character of land use development and transportation systems.
Two obvious user fees with which to reduce current subsidies are the registration fee or wheel tax and the gasoline tax. Both are extensively used at highly varying rates. A wheel tax implemented at the local level has the distinct advantage of allowing local units of government, including counties, to determine their level of transportation expenditures and associated fees. This provides greater flexibility in choosing land use and infrastructure configurations, particularly those that significantly reduce cost.

With either a wheel or gasoline tax, two important concerns are the tax rate and the equity implications of the taxes. I advocate that tax rates be set to at least fund the direct costs of local roads. In Madison, this fee would be about $150 per vehicle per year as noted in Table 4. Based on the expenditure levels shown in Table 2, there would be considerable variability across Wisconsin, with Milwaukee's fee at roughly $250 per vehicle.

Funding local highway costs by a wheel tax would allow other local taxes to be reduced. In the case of Wisconsin and many other states, this translates to a reduction in the general property tax. Evaluation of the incidence of a flat wheel tax versus a property tax shows the wheel tax to be somewhat more regressive on average (Collier 1985). However, a wheel tax that is relatively progressive can be achieved by setting a tax based on the value of the vehicle.

A gasoline tax has the advantage of more directly relating
highway use to taxes collected. It has the disadvantage, however, of the loss of local control as a gasoline tax would probably have to be imposed at the state level and the tax would be burdensome for low income households. If equity and local control are important considerations, a progressive wheel tax determined at the local level is more desirable.

The complexity of the land use development process is such that the results of any user fee can be predicted only in terms of the direction of movement towards more compact settlement patterns.

A second policy direction, which is clearly inferior but might be of interest in certain policy situations, is to provide increased subsidies for other modes of travel, thereby increasing their desirability. Where this policy option is of most interest is in urban areas which are: 1) already built, 2) not growing spatially, and 3) are unwilling to alter the present patterns of automobile subsidy. In this situation, land use is already determined but travel behavior might be altered. Modal competition and equity arguments can be made to reconsider subsidies to mass transit and other modes.

Eliminating the indirect subsidies is a more complex task. It could require specifically addressing each of the items identified as an externality. For example, the health costs could be provided by separate insurance pools for highway related medical costs. Air pollution costs could be further internalized by increasing the emission standards, for example to the stricter
Japanese standards. The wisdom of each policy would have to be scrutinized.

A very different response to indirect subsidies is to focus policy on sending appropriate price signals by way of national fuel taxes set, based on Table 4, at roughly $.75 per gallon. Annual revenues of $90 billion could be used as general fund revenues. This is similar to policy in much of Europe and is in accord with recent discussions in the United States to reduce the federal deficit and respond to increasing oil imports and decreasing domestic oil production.

If communities are to develop with less sprawl and low density development, they will have to do something more than zone, educate the public, and build infrastructure to accommodate development. Communities will have to consider land markets and incentives as well as physical planning factors if they are to guide development. Physical planning by itself is a weak a process for communities to meaningfully guide the character of development. Eliminating or reducing existing automobile subsidies is a necessary change in policy if communities hope to significantly redistribute "competitive opportunities" and alter the course of development.
FOOTNOTES

1. See Rodriguez-Bachiller (1986) for a comprehensive review of this literature.

2. Per capita county highway cost funded by local revenues is derived from Ammerman and Novak (1989).

3. This per capita subsidy figure is the local subsidy, i.e. from local general revenues. Mass transit receives funds from state and federal sources as well. For example, Wisconsin state aids to transit systems have been set at 37.5% of operating costs since 1986. This was equivalent to over $6 million in Madison in 1987 (Wisconsin Department of Transportation 1989). Including these state aids increases the per capita transit subsidy to $57. The determination of a defensible basis of comparison of subsidies between the automobile and mass transit is a question beyond the scope of this paper.

4. Previous highway aid formulas were more generous to rural areas. As aid formulas have changed since the mid 1970's to provide rural areas with relatively less aid, the Wisconsin Legislature has not allowed the absolute amount of aid to a specific municipality to diminish (Ammerman 1985). The tax payers of towns also pay a portion of their county levy for county highways.

5. This estimate ignores adjustments for tax base equalization.

6. Wisconsin statutes provide for a local registration fee in addition to and collected with the state registration fee.

7. The difficulty with uniform state (or national) registration fees and fuel taxes is that they restrict the flexibility of
local units of government in determining transportation expenditures. Local units of government construct roadway infrastructure to recover as much funds as possible, even if expenditures are larger or different than what they would otherwise choose.

8. This is in addition to the state registration fee of $25 per year.

9. The impact on the property tax in Wisconsin of funding local highway costs with a wheel tax can be approximated by eliminating net highway expenditures in Table 2. The aggregate effect in 1987 of adopting a wheel tax to fund the 76% of local highway costs not funded by state highway aids is to reduce the local tax levy for all municipalities from $1.2 billion (Wisconsin Department of Revenue 1989) to $620 million, ignoring adjustments for state shared revenues.

10. This is highly dependent on vehicle ownership, however, and 43% of households in Madison with money income of less than $10,000 do not own vehicles.

11. For example, Crandall et. al. (1986) found that existing U.S. emission standards do not stand up to benefit-cost evaluation.

12. This assumes a tax on gasoline and diesel motor fuels and a zero price elasticity of fuel consumption.
REFERENCES


Governor's (of Wisconsin) Special Committee on Transportation Aids. 1982a. Report to the Governor from the Special Committee on Transportation Aids.

Governor's (of Wisconsin) Special Committee on Transportation Aids. 1982b. The Distribution of Local Highway Aids in Other States. Paper #10.


Table 1. Distribution of 1989 Transportation Aid Payments in Wisconsin ($ millions)

<table>
<thead>
<tr>
<th>Jurisdiction</th>
<th>Estimated 1989 Payments</th>
<th>Percentage of Reported 1987 Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Counties</td>
<td>57</td>
<td>30%</td>
</tr>
<tr>
<td>Towns</td>
<td>49</td>
<td>36%</td>
</tr>
<tr>
<td>Incorporated Areas:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 10,000</td>
<td>25</td>
<td>18%</td>
</tr>
<tr>
<td>10,000-35,000</td>
<td>25</td>
<td>21%</td>
</tr>
<tr>
<td>35,000-200,000</td>
<td>26</td>
<td>21%</td>
</tr>
<tr>
<td>Milwaukee</td>
<td>23</td>
<td>22%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>206</td>
<td>25%*</td>
</tr>
</tbody>
</table>

* 25% of $817 million reported costs in 1987

Source: (Ammerman and Novak 1989)
Table 2. Transportation Expenditures Relative to Property Taxes in Selected Wisconsin Municipalities in 1987

<table>
<thead>
<tr>
<th></th>
<th>Milwaukee</th>
<th>Madison</th>
<th>Town of Hubbard</th>
<th>Town of Middleton</th>
<th>Town of Primrose</th>
<th>Town of Vermont</th>
</tr>
</thead>
<tbody>
<tr>
<td>total property tax ($1000's)$</td>
<td>448,043</td>
<td>155,430</td>
<td>109</td>
<td>3,189</td>
<td>647</td>
<td>659</td>
</tr>
<tr>
<td>state tax credits ($1000's)$</td>
<td>66,156</td>
<td>18,425</td>
<td>20</td>
<td>553</td>
<td>114</td>
<td>113</td>
</tr>
<tr>
<td>net property tax ($1000's)$</td>
<td>381,887</td>
<td>137,005</td>
<td>89</td>
<td>2,636</td>
<td>533</td>
<td>546</td>
</tr>
<tr>
<td>school tax levy ($1000's)$</td>
<td>185,369</td>
<td>80,897</td>
<td>71</td>
<td>2,184</td>
<td>415</td>
<td>429</td>
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<tr>
<td>other tax levy ($1000's)$</td>
<td>125,337</td>
<td>29,890</td>
<td>36</td>
<td>880</td>
<td>166</td>
<td>153</td>
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<tr>
<td>local tax levy ($1000's)$</td>
<td>137,337</td>
<td>44,733</td>
<td>3</td>
<td>125</td>
<td>66</td>
<td>77</td>
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<tr>
<td>highway expenditures ($1000's)$</td>
<td>106,722</td>
<td>18,455</td>
<td>36</td>
<td>185</td>
<td>63</td>
<td>101</td>
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<tr>
<td>state aid at 24% ($1000's)</td>
<td>25,613</td>
<td>4,429</td>
<td>9</td>
<td>44</td>
<td>15</td>
<td>24</td>
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<tr>
<td>actual aid payments ($1000's)$</td>
<td>21,935</td>
<td>3,933</td>
<td>15</td>
<td>35</td>
<td>28</td>
<td>26</td>
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<tr>
<td>net highway expenditures ($1000's)$</td>
<td>81,109</td>
<td>14,026</td>
<td>27</td>
<td>141</td>
<td>48</td>
<td>77</td>
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<tr>
<td>population (number)$</td>
<td>608,442</td>
<td>175,664</td>
<td>242</td>
<td>3,098</td>
<td>626</td>
<td>631</td>
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<tr>
<td>net highway expenditures per capita ($')</td>
<td>133</td>
<td>80</td>
<td>113</td>
<td>45</td>
<td>76</td>
<td>111</td>
</tr>
<tr>
<td>net highway expenditures as a percentage of the local tax levy (%)</td>
<td>59%</td>
<td>31%</td>
<td>101%</td>
<td>112%</td>
<td>73%</td>
<td>100%</td>
</tr>
</tbody>
</table>

+ source: (Wisconsin Department of Revenue 1989)

* source: (Meinholz 1989)

& Net highway expenditures are based on 24% of expenditures to reflect new statutory requirements. They differ from actual payments shown due to the new requirements and the hold harmless provisions in the statutes.
Table 3. Madison, Wisconsin Highway Expenditures and Subsidies for 1983
(1000's of 1983 dollars)

<table>
<thead>
<tr>
<th></th>
<th>Total Aidable Expenditures</th>
<th>Billings to Other Parties</th>
<th>Federal Aid</th>
<th>State Aid</th>
<th>Total Direct Expenditures</th>
<th>State Highway General Aid</th>
<th>General Revenue Expenditures i.e. Direct Subsidies</th>
<th>Externalities and Other Indirect Subsidies</th>
<th>Total Subsidies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highway Infrastructure</td>
<td></td>
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<td></td>
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<tr>
<td>construction</td>
<td>5,268</td>
<td>97</td>
<td>392</td>
<td>330</td>
<td>6,087</td>
<td>1,359</td>
<td>3,899</td>
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<tr>
<td>maintenance</td>
<td>3,298</td>
<td></td>
<td>3,298</td>
<td></td>
<td></td>
<td>857</td>
<td>2,441</td>
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<td>2,441</td>
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<tr>
<td>other</td>
<td>2,198</td>
<td></td>
<td>2,198</td>
<td></td>
<td></td>
<td>571</td>
<td>1,627</td>
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<td>1,627</td>
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<tr>
<td>Traffic Police Costs</td>
<td>5,058</td>
<td>1,969</td>
<td></td>
<td></td>
<td>5,058</td>
<td>1,315</td>
<td>3,743</td>
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<td>Environmental Impacts</td>
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<td>air pollution</td>
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<td>water pollution-salt</td>
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<tr>
<td>Human Impacts</td>
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<tr>
<td>personal injury</td>
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<tr>
<td>property damage</td>
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<tr>
<td>lost earnings</td>
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<td></td>
<td></td>
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<tr>
<td>Land Use Opportunity Costs</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Petroleum Subsidy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>15,822</strong></td>
<td><strong>6,923</strong></td>
<td><strong>392</strong></td>
<td><strong>330</strong></td>
<td><strong>16,641</strong></td>
<td><strong>4,113</strong></td>
<td><strong>11,709</strong></td>
<td></td>
<td><strong>34,430</strong></td>
</tr>
</tbody>
</table>

Source: Columns 2-8 (Meinholz 1989)

Column 9 as noted in text

Column 10 is the sum of columns 9 and 10
<table>
<thead>
<tr>
<th>Subsidy Type</th>
<th>Amount</th>
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</thead>
<tbody>
<tr>
<td>Per capita direct subsidy</td>
<td>$105</td>
</tr>
<tr>
<td>Per capita indirect subsidy</td>
<td>$152</td>
</tr>
<tr>
<td>Per capita total subsidy</td>
<td>$257</td>
</tr>
<tr>
<td>Per vehicle direct subsidy</td>
<td>$150</td>
</tr>
<tr>
<td>Per vehicle indirect subsidy</td>
<td>$262</td>
</tr>
<tr>
<td>Per vehicle total subsidy</td>
<td>$412</td>
</tr>
<tr>
<td>Per passenger-mile direct subsidy</td>
<td>$0.024</td>
</tr>
<tr>
<td>Per passenger-mile indirect subsidy</td>
<td>$0.034</td>
</tr>
<tr>
<td>Per passenger-mile total subsidy</td>
<td>$0.058</td>
</tr>
<tr>
<td>Per gallon direct subsidy</td>
<td>$0.53</td>
</tr>
<tr>
<td>Per gallon indirect subsidy</td>
<td>$0.74</td>
</tr>
<tr>
<td>Per gallon total subsidy</td>
<td>$1.27</td>
</tr>
</tbody>
</table>
Figure 1: Changes in the Cost of Transportation

Figure 2: Changes in Population Density and Unit Rent
Local and Wis-DOT Highway Spending

1978–85 in Constant 1983 Dollars

Figure 3. Source: Wis-DOT and LFB

Local  
Wis-DOT