URBAN STRUCTURE AND ITS INFLUENCE ON VEHICLE TRAVEL REDUCTION STRATEGIES

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Urban Structure and Its Influence on Vehicle Travel Reduction Strategies

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SUMMARY

This paper examines what is known about the relationship between urban spatial structure (i.e. the arrangement of residential, industrial, commercial, recreational and municipal buildings and land lots) and urban travel. The first section provides an overview of the empirical evidence for relationships between urban spatial structure and travel in the United States. Section two focuses on the barriers to and opportunities for reducing the use of automobiles and light trucks in urban areas. The final section offers a policy-point-of-impact perspective on the sort of instruments governments have at their disposal for reducing vehicular travel.

INTRODUCTION

The seeds of urban traffic growth, and the increased fuel use and air pollution associated with this growth, are found in the physical layout of geographically expanding cities, and in the demands of a growing and increasingly mobile urban population. The basic problem is that more fuel and time are required to move between broadly dispersed structures than denser, more narrowly spaced ones. If traffic growth is to be reduced significantly analysts and policy makers will need to consider policies that deal with urban land use arrangements as well as with the behavioral aspects of travel itself. A reassessment is required of how land owners, land developers, planning agencies, and the private sector determine the spatial arrangements and activity levels associated with urban land use. Governments need to better understand and plan for the ways in which individual travellers and businesses adapt their travel patterns to ongoing, and often difficult to reverse land use and infrastructure development trends. Transportation-efficient arrangements of land use are taken here to mean arrangements of land which maintain suitable levels of accessibility to opportunities and services with a minimum of vehicle use. Effective policies would lead to reduced vehicular tripmaking, shorter trip lengths, less congested travel and/or shifts from the automobile to either walking or cycling, or to ridership in higher occupancy vehicles (HOVs) such as rail and bus transit, and ridesharing (carpooling, vanpooling) arrangements.

This paper examines what is known about the relationship between urban spatial structure and urban travel. The material is based on a recent report by Southworth and Jones (1995), which addresses the following three questions (1) How does urban spatial restructuring affect the demand for travel? (2) What barriers and opportunities exist are associated with such restructuring?, and (3) What policy instruments can be applied by government to alter current
urban spatial structures in ways that might reduce aggregate vehicle travel. (No recommendations are made as to which instruments ought to be adopted).

CURRENT TRENDS IN TRAVEL AND URBAN STRUCTURE IN UNITED STATES CITIES

Between 1970 and 1991, total passenger miles travelled by automobile and light trucks in the United States increased by 38 percent, from some 2,109 billion to 2,903 billion miles. The energy used in this travel increased by 25.6 percent from 9,230 trillion to 11,594 trillion Btu (Davis 1994). Most of the discrepancy between these two rates of increase can be attributed to a more energy efficient vehicle fleet. However, while technological advances in vehicle performance and the use of cleaner fuels have made major impacts on automotive fuel consumption and emissions, these reductions have been offset by continued traffic growth and its associated congestion.

Between 1960 and 1990 vehicle miles travelled (vmt) on US highways grew more than 3% a year (Federal Highway Administration, 1994). Even with the implementation of transportation demand management programs in major US cities, the number of private vehicle commutes rose by 135.5%, and transit ridership fell from 7.8% to 5.9% between 1960 and 1990. Over this same thirty year period the average distance of daily commutes increased by 15% per person and by 18% per vehicle. There has also been a marked reduction in average vehicle occupancy, from 1.9 persons in 1977 to 1.6 in 1990 (Hu and Young, 1994). Causes of this growth in travel include inexpensive gasoline; the low costs of automobile operation; an extensive highway construction program including interstate highways radiating from and around major cities; low cost suburban housing; and increased retail, commercial, and industrial development in suburbs. While vmt growth rates are expected to fall off in the coming decades, due in part to near saturation in driver license holding, projected population increases in urban counties seem likely to fuel further demands for travel.

One way in which the largest cities appear to have responded to the problems posed by urban traffic congestion has been to spread out their land area while at the same time grouping employment and other non-residential activities around suburban activity centers. In so doing the United States is undergoing an evolution from unicentric to polynucleated metropolitan areas. The suburban centers of these polynucleated cities provide many of the employment, shopping, and entertainment functions that were formally found only within their central areas. The largest of these subcenters now operate as semi-autonomous “edge cities” (Garreau, 1991) and are experiencing their own versions of worsening urban traffic congestion.

As for the scientific evidence, a number of empirical and simulation modeling studies have looked at the relationship between urban land use and transportation systems over time (notably Keyes, 1982; Newman and Kenworthy, 1989; Gordon, Kumar, and Richardson, 1991; and Watterson, 1993). Many of these studies were in response to the energy crises of the 1970’s. This evidence suggests that urban spatial structure, notably through the intensity (density) and spatial clustering of different land uses, may account for 40 to 50 percent of the variation in urban travel across
different US cities. However, it also suggests that further significant changes in spatial pattern, such as increases in urban density, will be needed to bring about even modest VMT reductions and associated transportation energy savings. Getting reductions in aggregate vehicle miles travelled or fuel consumed of more than 11 or 12 percent would appear to be a very challenging task if these studies are correct. However, Southworth and Jones (1995), in reviewing this literature, found the reliable scientific evidence to be limited, with several gaps in our current understanding of the relationships involved. One weakness of past studies has been too strong a focus on reducing peak period traffic congestion, rather than on reducing total travel. Such an approach neglects considerable amounts of non-work travel and the relationship between commuting and other household travel activities. A second problem with past studies has been the limited data and methods used to support a detailed geographic disaggregation of the urban structural variables (notably the land use mix) within and across different cities, and over time. Third, the use of historical evidence to estimate cause and effect relationships incorporates the effects of highly fragmented local land use controls that are often inefficient with respect to total travel. In contrast, the more idealized simulation studies of urban structure and travel demand, while sometimes more optimistic in their representation of urban restructuring’s potential to affect VMT, have a tendency to oversimplify the functional relationships between increased urban densities, greater land use mixing, and aggregate, multimodal transportation supply and demand. Finally, no studies to date have quantified in a comprehensive manner the full social and financial as well as environmental costs of the different urban restructuring options they simulate. In short, more empirical research needs to be done.

SOME BARRIERS AND OPPORTUNITIES

There are at least five major barriers to significant travel reduction: (1) inertia in the existing infrastructure supply; (2) lack of coordinated, metropolitan area-wide land use planning; (3) high mobility levels and demands for scheduling flexibility, both associated with, and further encouraged by, automobile use; (4) demographic trends toward more households and more drivers per household; and (5) the possibility of conflicting societal goals within the transportation planning process.

BARRIERS.

(1) There is considerable inertia associated with the capital invested in the locations of the current urban infrastructure, that is, investments in residential neighbourhoods, commercial buildings, industrial parks, shopping centers, recreational facilities, and in the highways and rail transit lines that connect them. The necessary water, sewer, electrical, and gas lines are also included in this infrastructure. Most of these services are hierarchically structured for efficiency. Extending such services more than a mile or so from the end of existing trunk lines often involves significant additional investments. The same lumpiness in investment requirements is often true with other community supported services such as schools, hospitals, fire and police stations, health clinics, and community centers. This means that new suburban land developments projects, which have had a tendency to increase in size, need to be carefully planned. Once in place they can incur considerable costs to either shrink or expand.
(2) There is a multitude of jurisdictions in most US metropolitan areas. On average, about 100 different forms of government are involved in their management, including state and regional planning organizations, councils of government, counties, cities, townships, school and other special purpose districts. In many cases, suburban areas outside the bounds of the city government will incorporate to prevent a city from expanding its control to these hinterland areas. This prevents consistent land use policies from being applied across the metropolitan area and diminishes the central city’s ability to fund operations, to carry out maintenance or to expand its public works programs in transportation and other areas. Suburban and central cities often have used zoning and annexation as weapons in conflict with each other, instead of working in cooperation to develop transportation efficient area-wide land use strategies.

(3) Traveller attitudes toward travel have also changed, and continue to do so. Over the past fifty years US society has become highly mobile and time is an increasingly valuable commodity. Temporal travel budgets therefore favour private vehicle use. Currently, only the automobile can allow multi-purpose, multi-destination trip chaining: such as a daily tour from home -> work -> school -> evening shopping and then home again. (In the freight sector the movement toward speedy package delivery and a just-in-time industrial production philosophy also seems likely to increase the frequency of delivery truck traffic within metropolitan areas).

(4) Recent demographic and socioeconomic trends have resulted in increased household travel. The United States is moving towards more households and more drivers per household. Average household size declined from 3.33 in 1960 to 2.63 in 1990. Women are also driving more for both work and non-work purposes. There has also been growth in the number of two worker households, with the use of automobiles by both adults. As children grow to driving age, they now commonly acquire driving licenses and drive to school as well as to other destinations. With so many drivers in the household and so many different destinations to visit, there is today a multitude of forces determining housing location, not just the location of a single employer as was frequently true thirty years ago. Also, with people now remaining with their current employer for shorter periods (on average, around 4.5 years) the potential exists for within-community, mixed-land use-based travel reduction schemes to loose their value to workers who must now travel to other communities or suburbs during the work week. Currently a large percentage of the laborforce works outside its community of residence in large US cities. Over time this makes for a difficult to interpret, two-way functional relationship between home and job locational choices and the many travel (notably, destination) choices available to household members. For many households, job location may still be the primary influence on residence location. For other households residential preference may be the primary determinant, based in part on family access to shopping, recreation, schools, friends and other place specific opportunities. A longer commute for one wage earner may be an acceptable price to pay for this greater general accessibility.

(5) Like individual travellers, urban planners are faced with multiple competing objectives. There are today a number of reasons for wanting to control urban traffic growth. These include the desire to reduce delays from traffic congestion and the desire to limit fossil fuel use in support of cleaner air, as well as greater energy security (at the national level) and lower driving costs. However, it is possible that more gasoline may be consumed as the result of specific travel...
reduction schemes which reduce the incidence of congested stop-and-go traffic at the expense of longer, more circuitous trips. Also, while a high correlation exists between vmt and carbon dioxide emissions, it is still unclear what effects different traffic conditions have on the marginal generation of criterion gases such as CO, HC and NOX. If people move toward more compact, higher density living, but do not reduce private vehicle use sufficiently, some urban environments could become less healthy by trapping heat and helping to concentrate carbon monoxide along congested urban corridors.

OPPORTUNITIES.

Opportunities to reduce travel may also exist through (1) the use of telecommunications technologies that can substitute for travel; (2) recent environmentally motivated federal legislation that requires greater coordination of local and metropolitan area-wide transportation plans; and (3) the fact that most daily travel is now non-work related, and hence more discretionary in its timing or choice of destination.

(1) Telecommuting is now practiced by more than 2 million workers in the United States. This could increase to between 7.5 and 15 million in the next decade (US DOT, 1993). It has been suggested that telecommuting may encourage further urban sprawl, and by allowing workers to be even more footloose in the selection of residences, the benefits of reduced trip frequency might be offset by less frequent, but longer commuting. Alternatively, if numerous satellite telework centers emerge within the suburbs, commuting distances may be reduced. How this would affect the rest of a household’s travel activity pattern remains largely speculation at the present time, however. Given the potential for not just telecommuting but also teleshopping and other forms of telecommunications to affect travel choices more research is needed to assess the aggregate vmt impacts.

(2) Where major transportation system improvements are concerned, decision making involves metropolitan, state, and Federal funds. In the United States, Federal legislation in the form of the 1990 Clean Air Act Amendments (CAAA) and 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) promotes coordinated planning at the metropolitan area-wide level. The CAAA require compliance with national ambient air quality standards for carbon monoxide, particulate matter, ozone, nitrogen dioxide, lead and sulphur dioxide. Since some forms of air pollution present a metropolitan area-wide problem, this legislation has forced different metropolitan political entities to work together to achieve these goals. The ISTEA also provides legislative support for metropolitan governments to improve air quality, by funding long range transportation planning and air quality programs and by allowing flexibility in the allocation of funds to programs that encourage alternatives to private vehicle travel. How the nation’s Metropolitan Planning Organizations will take advantage of this legislation remains to be seen.

(3) The 1990 National Personal Transportation Survey indicated that shopping, personal business, and other non-work related travel is now responsible for 79 percent of total person miles travelled. Shopping trip mileage per household increased by 88% between 1969 and 1990, and other family and personal business by 137% (Hu and Young, 1994). Much of this increase in vmt was due to more trips being made. Surprisingly, a good deal of this non-work and non-school
travel also takes place during the peak commuting hours. Policies that encourage more efficiently organized mixes of traffic generating and attracting land use therefore may present an opportunity for travel or congestion reduction. For example, mixing activities on land developments that can serve different categories of demand may encourage walking or cycling on shorter trips or the use of efficient multi-purpose trip chaining practices where longer connections are required. However, just how much of this non-work travel is truly “discretionary” in both time and space is not always clear and warrants further study.

POSSIBLE TRAVEL REDUCING POLICY INSTRUMENTS

Numerous travel reducing policy instruments have been proposed, and many experimented with, in the United States. To facilitate discussion of a complex topic, Southworth and Jones (1995) group these instruments according to their policy-point-of-impact. This includes (1) instruments that act directly on traffic generating and attracting infrastructures; (2) instruments that directly determine the type, location and capacity of transportation infrastructures; and (3) instruments that act directly on the day-to-day use of this urban infrastructure, including choices of vehicle, travel frequency, mode, route, time of day, and destination.

Category 1 offers a varied set of instruments. It includes various methods of land use zoning, including efforts to increase land use densities and mix (see Cervero, 1989 for a categorization); and the use of fee bargaining between local governments and private land developers (see Nelson et al., 1990) to control physical development. Category 1 also includes the introduction of community-wide urban designs, including the layout of local street patterns in which the impact of the automobile within neighborhoods is carefully controlled. This includes recent efforts to promote traffic efficient arrangements of community land according to the neo-traditional principles of the “new urbanism” movement, and a growing interest in both pedestrian-oriented and transit-oriented land development. In reviewing this area Ryan and McNally (1995) refer to a handful of recent studies that claim considerable potential for intra-community travel reductions. A very different set of Category 1 instruments includes globally applied personal and business taxation schemes. These run the gamut from inter-community revenue sharing schemes geared to discouraging localized fiscal zoning (to deter unprofitable land uses and hence reduce land use mixing), to broader based, federal tax instruments. At present, however, little is known about the differential spatial impacts these fiscal instruments may have on long term urban restructuring.

Category 2 instruments are, in contrast, limited to large public investment in the transportation infrastructure, primarily in new or expanded highways, rail transit lines, and terminals. The potential effects of such investments have generated a good deal of debate in recent years. Much of this has occurred in response to claims that adding road capacity simply induces more travel and therefore uses more fuel and adds more pollutants to the atmosphere. However, well documented weaknesses in our current transportation planning models (Southworth, 1995) mean that we are often uncertain whether added transportation capacity reduces pollution and fuel consumption by alleviating congestion, whether it simply shifts travel and related activities to other intraurban locations, reduces travel by reducing trip lengths, or actually induces more travel,
including the translation of latent travel demands into new vmt, as a result of improved intraurban accessibility (see, for example, Kitamura, 1994).

Policy instruments that might be considered under Category 3 include a variety of so-called Transportation System Management (TSM), Transportation Demand Management (TDM) and Transportation Control Measures (TCM) that have in the past been geared largely to mitigating urban traffic congestion during the daily peak commuting hours. A promising option and a growing activity in the United States is the use of High Occupancy Vehicle (HOV) lanes, in cities such as Houston, Seattle, and Washington, D.C.

Category 3 also includes various forms of travel pricing instrument. This includes vehicle use-based pricing (including fuel taxes, emissions and related pay at-the-pump pricing schemes). It also includes vehicle ownership based pricing schemes and a growing number of ways to use modern technology to collect time-of-day, location- or duration-based congestion management or vehicle parking fees, possibly linked to area-based parking controls (see May 1994). While pricing instruments and parking controls could do much to alleviate traffic congestion and control urban travel demands, such policies would be very unpopular with the driving public.

Currently there is a good deal of uncertainty and consequently conflicting views among planners and other experts as to what we should expect from applying different combinations of the above policy instruments. Can better urban designs, coupled with TDM and TSM strategies, as well as various fiscal incentives reduce inter-community as well as intra-community vmt, aggregate fuel use and emissions? The existing empirical as well as theoretical evidence is mixed. Certainly, some packaging of these different instruments, and categories of instruments, is likely to be necessary. For policies to work, however, policy makers will need to recognize the longer term character and metropolitan area-wide scope of urban land use planning and its need for coordination with multi-year regional transportation plans. Southworth and Jones (1995) provide more information on these instruments and a review of some current evidence and views regarding their potential for socially acceptable vehicle travel reduction.

CONCLUSIONS

There is still some way to go in tackling the urban traffic growth problem effectively, and much more can be learned about the complex cycles of cause-and-effect linking travel to spatial structure. More research is needed, taking advantage of new spatial data bases and decision support tools such as geographic information systems. Tapping into the wealth of traffic information from Intelligent Transportation System technologies should also provide new insights. Making use of this data, a better understanding of our urban land use and transportation development options should result if investigators incorporate the following into their efforts:

1) Deal with the causes and constraints of complete household travel activity patterns, not simply commuting.
2) Develop a better understanding of the role of suburban employment centers in the geographic expansion of modern metropolitan areas. In particular, develop methods to predict the timing and location of the next subcenter or the emergence of the next "edge city", and
develop methods to assess its capacity to reduce travel and fuel use for both work and non-work related activities.

3) Recognize the increasingly footloose, and often temporary, nature of both residential and employment locations within modern society, and examine the long term (multi-year) benefits of alternative urban land use arrangements and transportation supply options in this context.

4) Inform the public debate with a more comprehensive accounting of the full social, as well as financial and environmental costs and benefits of urban structural change, including costs to travellers, businesses, and the rest of society.

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