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THE SOCIOLOGY OF TRANSPORTATION

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Abstract

This article provides a comprehensive review of developments in transportation research relevant to sociological inquiry about urban transportation and its consequences for urban structure, both spatial and social. Recent research has gone beyond initial observations about the linkages between transportation use and the spatial form of cities to further detail its impacts upon residential segregation, decentralization, and inequalities in mobility access. Historical case studies of local transit firms and politics, industrial organization of the transportation industry and its impact upon transportation policy, and national and local studies of the political economy of urban transporation have advanced a comparative research framework for understanding the institutional forces that constrain transportation choices and technical development. Finally, social psychological research, through laboratory experimental studies, field studies, and time-budget analysis, has just begun to examine the impacts of transportation upon social interaction in the family and community. This literature review concludes with proposed research questions for future investigations.

INTRODUCTION

Transportation centrally affects the relationship between physical space and society. That changes in transportation affect the organization of human activity in urban and regional space, structuring the built environment, spurring urban growth, and ordering the relationships among cities in a national urban system, has been widely recognized since the origins of social research about the interdependence between urban society and technology.

Refining initial observations, recent research differentiates the impacts of

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transportation spatially and socially. The assumption of early ecologists and geographers that urban dwellers would gain universal access to housing, employment, education, and services has given way to study of transportation's impact upon residential segregation, decentralized and polycentric land use patterns, energy use, and inequity in the distribution of transportation services. Attention has also been directed to the social impact of these inequities—mismatch between residential location and employment opportunities among the urban poor, and social isolation of youth, aged, handicapped, racial and ethnic minorities, and women.

Over the past decade, social psychologists have begun to refine further these macro-social structural impacts by examining how transportation affects individual social interaction in the family and community. Laboratory experimental studies, field studies in natural settings, and time-budget analyses suggest the depth of transportation impacts upon daily lives.

Another emerging body of research focuses upon the institutional forces that have shaped transportation technology. This research, drawn from urban history, policy organization studies, and urban political economy, fills in theoretical gaps in earlier transportation work. It includes historical treatments of local transit operating systems, investigations of how the industrial organization of the transportation industry affects policy in that area, and national and local studies of transportation policy formation.

TRANSPORTATION AND ECOLOGICAL PROCESSES

Urbanization requires the coordination and geographical concentration of specialized economic activities (Rostow 1962; Tilly 1974). Both coordination between urban centers and concentration of population within regions are advanced or retarded by changes in transportation and communication technology. Preliminary concentrations of population in urban centers, made possible by inter-regional transportation (e.g. canals, railroads, highways), are followed by population dispersals as centralized economic activities spill over into broader metropolitan regions through further intra-urban transportation developments (e.g. streetcar electrification or the advent of automobiles).

Ecological research has largely reduced the theoretical explanation of urban processes to these sorts of technological changes. From this research perspective, urban population grew as a result of increased participation by cities in inter-regional economies made possible through technological advances in transportation (Berry & Garrison 1958; Berry 1979; Isard 1960; Berry & Horton 1970). These transportation changes extended the supply of urban land for settlement and connected settlements throughout the country. Urban expansion and the evolution of a national urban system were promoted through transportation advances (Pred 1974). As one mode of transportation reached its technological limits in extending urban space, another would take its place.

Successive changes in motive power characterized new periods of urban form (e.g. the pedestrian city, the streetcar suburb, and the auto metropolis).

As branch lines of horse-drawn trolleys, electrical trams, and steam railways extended, they created a star-shaped, axial pattern of urban growth. Later, automobiles developed the spaces between the axes of this star-shaped pattern, developing a circular urban structure. Central city congestion then encouraged residential and industrial decentralization (Park 1952:171–77; McKenzie 1968:9–18; Hawley 1950:382–85; Hawley 1970:242–45). Changes in transportation mode extended urban boundaries, increasing the need for transportation along the urban periphery. The urban-ecological perspective focuses upon the direct impact of transportation technology upon urban growth.

Cross-sectional research has meanwhile attempted to account for variation in the level and mix of transportation services between cities. If changes in transportation technology affect the size and form of urban settlement, then at any given time that ecological configuration should predict the extensity and mix of transportation services. Thus the causal order of transportation and urban ecology is reversed and cross-sectional evidence is used to support what is essentially a longitudinal theoretical argument—i.e. that the physical characteristics of cities (age, size, population density) predisposed them to "optimal" transportation solutions through both individuals' choices and the policies that reflected them.

The ecological characteristics that reflect a city's level of urbanization are said to be the primary determinants of that city's urban transportation system. Population size approximates the market scale for transportation services; population density estimates the economy of operation; and city age indicates the timing of the city's emergence as a metropolitan center (i.e. before or after automobilization), which determines the physical organization of the city and its adaptability to private or public transportation. The physical structure and settlement patterns of earlier urbanized cities were found more likely to be denser, optimizing access to and efficiency of public transportation. Urban research in both the United States (Hawley 1950; Schnore 1968) and Germany (Weber 1978; Losch 1952; Christaller 1966; Klemmer 1971; Iblher 1970) viewed transportation infrastructure as the outcome of the city's spatial organization and population characteristics.

This argument also underlies conventional explanations of the differences between European and US mass transit systems. National population density of Germany is higher than that of the United States, owing to pre-industrial and early industrial settlement patterns. The density and age characteristics of German cities allegedly account for their more advanced transport systems (Dunn 1981; Adams 1981). The same position is used to explain inter-city variations within countries, with older industrial cities more likely to have mass transit systems than newer, low-density cities.

A closer look suggests this argument oversimplifies the social processes of

transportation change. For example, though US population density in all urbanized areas combined is half that of Germany, the population size and density of the largest US metropolitan areas are the same or greater than those of the largest German cities. The greater proliferation of small and medium-sized cities in the US national urban system, not large differences between German and US major metropolitan centers, misleads researchers (through the logical error of misplaced specification) into arguing that ecological characteristics alone determine transportation outcomes.

The position that urban characteristics of size, age, and density determine demand for transit services is widely repeated in sociological and planning studies of US cities (Schnore 1968; Kain 1967; Guest & Cluett 1976; Council on Municipal Performance 1975; Leggitt 1976; Mamon & Marshall 1977). The large size of both correlation and multiple regression coefficients among these characteristics suggests spurious relations between them and mass transit; statistically, this indicates "multicolinearity"—i.e. that theoretically unspecified, unmeasured variables inflate the apparent effect of these urbanization characteristics upon the level of mass transit. This suggests that if urban characteristics prior to urbanization could be identified and controlled for, the observed relationship between ecological structure and transit would be reduced and more variance between cities would be explained.

Ecological theory about transportation has been largely incorporated into urban and transportation planning (Lowry 1959; Hansen 1959; Peat, Marwick, Mitchell, and Co. 1975; Daniels 1972; Putnam 1975; Cheslow & Olsson, 1975). In these planning models, as well as in Federal transit funding formulas, the ecological and spatial structure of cities are used to prescribe transportation policy thereby reinforcing existing travel patterns and promoting highways as solutions to congestion. A report on transportation planning studies commissioned by the US Department of Transportation discussed the theoretical and methodological weaknesses of this perspective:

> Even though an impressive amount of effort has been spent on this type of research, the results have been meager in view of the standards called for by the purposes and objectives stated in the studies. The technical reasons why an unsatisfactory amount of knowledge has come from these studies stem from their completely inadequate theoretical foundations and methodological approaches. These problems have crippled attempts to establish and evaluate transportation impacts (Charles River Associates 1972:4–5).

Though the physical structure of a city and the technological evolution of transportation technology are not unimportant, they are proxies for more generic historical processes. Research based solely upon cross-sectional data for the most recent census years cannot capture the social, political, and economic dynamics creating the built environment of cities. Similarly, transportation planning based upon such spatial and consumer-behavioral demand-modeling ignores the possible alternatives of coordinating the physical de-

velopment of cities with transportation changes and reinforces existing travel patterns.

Clearly, an association exists between the timing of urban growth and the city's emerging transportation system, but that alone cannot account for the wide variation in the application of transportation technology. The limitations in a given transportation technology's use are often political rather than technical. For example, the lack of crosstown route development, which would have more densely populated the interstices between urban rail routes, resulted from political decisions, not from the technical exigencies cited by urban ecologists on the basis of US research. In Europe, crosstown routes were the norm, while US interstitial development occurred later with the automobile. The causes of the difference are to be found in differences in urban and transportation policy concerning the ownership and control of transit operating companies, fare structures, and planning goals (Yago 1982), not in any inherent technological limitations of rail transportation. Ecological analysis sensitizes us to the impacts of spatial development upon urban development. To this must be added an historical analysis of such development—not only of the technological evolution in transportation that has helped to generate it, but also of the social forces that have constrained it.

TRANSPORTATION STUDIES IN URBAN ECONOMICS AND POLITICAL SCIENCE

The conclusions of urban economists and political scientists are similar to those of urban ecologists, though different explanations and evidence are offered about the role and consequence of urban transportation. Economists have elaborated ecological theory by focusing upon how firms and residential consumers of urban land choose to minimize locational costs. Assuming rational choice by consumers in their econometric models, the economists posit that consumers (industrial and individual alike) sought to balance land and travel costs as transportation technology increased access to cheaper land. Technological changes in transportation (e.g. motorization) removed residential, commercial, and manufacturing activities from locations in the urban core as firms and residents moved outward to minimize land costs. Thus technological change determined travel and land costs, changes in economic activity, and new economic functions affecting urban transportation.

This explanation does not refer to historical decisions and institutions that constrained land, transportation, housing, and commerical markets. As Muth (1969:47) asserts: "Many of the features of city structure and urban land use can be explained without reference to the heritage of the past." Consequently, most studies by both urban economists and urban political scientists have been limited to cross-sectional data; investigators have assumed that the impacts of

technological changes are reflected in changing settlement patterns. Time-series data and historical analysis are absent in this approach. Location theorists in urban economics ignore governmental intervention into the urban market that constrains, or private control of land development that expands, the limits of city growth (Norton 1979). While the interplay of land and transportation costs appears adequate in the baroque mathematical models of urban regional development, such models allow researchers to organize an analysis of urban transportation abstractly, without rooting that analysis in an understanding of urban history (e.g. Isard 1962).

Changes in urban physical structure are linked with transportation technology changes by focusing upon population characteristics of cities (income, age, race, auto ownership, education) (Mayer, Kain & Wohl 1972; Kain 1967; Kain & Beesley 1965:163–85; Richardson 1972:108). The assumption of this research is that consumers rationally choose a form of transportation according to their social and spatial position within the urban market. Examining the background characteristics of people and their choices of transportation for the journey to work, the researchers not surprisingly confirm that those with higher incomes who own automobiles are less likely to use public transit than those with lower incomes who do not own cars.

Political science researchers into urban transportation have developed a similar argument: State and city levels of expenditure on transportation are a function of the association between attitudinal and demographic characteristics of urban residents. Governmental expenditure policies thus mediate conflicting attitudes and needs of an urban population, translating them into state and city transportation policies. Rapid urbanization, a sense of civic responsibility, the presence of upper socioeconomic groups, and a racially and ethnically diverse population are associated with a more adequate level of public transportation service as well as increased highway spending (Leggitt 1974).

Research on these spatial, economic, and population correlates of transportation fails to explain how they evolved. It fails not only because theory does not specify statistical models of transportation demand, but also because it ignores the relationship between spatial and social categories of analysis. This literature describes those categories, but the lack of a temporal dimension in the methodological design limits the ability of these research efforts to pose relational questions about the links among urban space, economy, and society. The assumptions of locational theory in urban economics, of ecological theory in urban sociology and geography, and of pluralism in political science abstract urban spatial and population characteristics from the historical and institutional setting of social classes in cities. Earlier economic and political science research on urban transportation profiles the clientele of private versus public transportation modes, but fails to pose questions about the relations and competition among transportation modes, cities within a national urban sys-

tem, and classes or urban elites whose political and economic interests are linked to specific patterns of urban development and change.

The other assumption that should be critically examined is that the consumer rationally chooses a form of transportation according to his or her social and spatial position within the market. This individualized level of analysis ignores (*a*) historical, political, and economic institutions that shape the individual's decision-making environment and (*b*) how individuals or firms acquire resources to facilitate market decisions. The assumption that governmental policy decisions reflect consumer choices and mediate between diverse individual decisions to deliver the optimal mix of transportation services is also questionable. Again, the demand side of the transportation market is considered determinate, while the structure of the industry supplying transportation services and equipment is largely ignored.

These demand models of urban transportation, based largely on the notion that consumers vote with their wheels (Altschuler 1980), fail to take into account the narrow range of options available to travelers. If we look beyond the limited choices of the US market place in the post–World War II period for evidence of consumer preferences, a growing body of survey research indicates widespread consumer support for increased transit service, deemphasis of highway transportation, improved nonprofit public transportation, and rail service (King 1975; Simpson & Curtis 1969). The assumption that individual choice is dominant in the marketplace, rather than the product of market forces, leaves urban research blind to the institutions and processes that constrain such choice.

INDUSTRIAL ORGANIZATION, INSTITUTIONAL PROCESSES, AND THE DEVELOPMENT OF TRANSPORTATION POLICY

Local and comparative transportation history contributes to our understanding of the complex interaction between urban growth and transportation change. Because much of this historical research addresses a limited historical period, its findings cannot be generalized. Still, it addresses the important institutional changes of local politics.

Initial studies in urban transportation history describe how the limitations of horse-drawn trolley systems spurred the rapid innovation of electrified trolley lines in the context of rising public utility investment, land speculation, and rapid population growth (Ward 1971:131–34). Electrification proceeded faster in the United States than in Europe (McKay 1976). The electrification of transit paralleled the growth of both the national electrical supplies manufacturing industry (Passer 1953:250–55) and the local real estate industry (Hoyt 1933; Wilcox 1921; Weber 1974). Moreover, transportation was viewed by transit

owners and city planners alike as a "moral influence" in removing people from the deleterious environment of central cities (Tarr 1973; MacShane 1975; Warner 1976). The social function of transportation in reducing social conflict in local politics through spatial dispersion of the urban working population was widely recognized (Gordon 1978; Katznelson 1981).

As Cheape (1980:211) notes in his comparative study of US transit systems before World War I, transit expansion in the early 20th century represented a social overhead investment to encourage regional development by private enterprise. The needs of mechanization and transit service were subordinated to these developmental goals. By World War I, this led to a combination of corruption and poor management resulting in a credit collapse and massive private disinvestment in transit (Smerk 1975:135).

At the local level, the increased militance of transit unions, some of the first labor organizations in US cities, drove labor costs considerably over the industrial wage average. The lack of extensive service and growing fare levels politicized transit among consumers as well, leading to increased demands for public control. Virtually every US city was the scene of legal battles, referenda over fare hikes, public ownership campaigns, and investigations of transit corruption (Miller 1960; Warner 1968; MacShane 1974; Holli 1969; Crooks 1968; Jackson 1969; Bean 1968; Fogelson 1967).

Transit regulation quickly ensued (Jensen 1956; Cheape 1980). Regulation depoliticized transportation, removing it from the public sphere of urban politics to the forums of appointed, business-oriented state regulatory commissions. This organizationally insulated transportation decisions from the public by the de facto disenfranchisement of the urban population.

Urban historians have often attempted to account for public transit's decline by citing some single cause—corruption (Smerk 1968), poor business practices (Hilton & Due 1968), overcrowded service (Holt 1972), the lack of technological innovation (Solomon 1971), regulation (Barrett 1975), or the rise of the automobile (Rae 1965). Although all of these factors played a role, they require explanatory linkages to account for the broader social structural shift surrounding the shift from public to private transportation modes. This change heralded not merely the technological shift from rail to rubber-wheeled vehicles; it also affected basic relations between labor and capital in the production of transportation equipment, consumer costs of job-related travel, and the political organization and administration of transportation policy. The shift to private transportation modes allowed the socialization of transportation-infrastructural expenditure through federal and state road building and publicly financed transit, depoliticized transit issues in electoral politics, and released investment capital from public infrastructural requirements.

Studies of both the labor process and the industrial organization of transportation increase our understanding of the social processes affecting transportation change. Variation in class relations and the organization of industrial

production have led to differential outcomes in the form and availability of transportation technology. In Europe, the content and extent of mechanization in the automobile industry greatly affected the cost of automobiles and the role of that industry in transportation policy. Craft traditions and strong skilled-labor unions in European auto industries retarded implementation of the assembly line and thereby delayed private motorization. Thus the extensive mechanization and assembly-line workplace organization central to the rise of mass production were largely resisted in Europe before the Depression. Thus class relations in production, by delaying full-scale mechanization of the labor process, affected the speed of corporate growth and concentration in the automobile industry. Along with established industrial and financial interests inhibiting motorization, this retarded proliferation of automobiles in Europe (Klapper 1910; Pflug 1929; Yago 1983).

In the United States, supporting industries for motorization (e.g. petroleum and rubber) emerged along with the automobile industry to become the largest and most concentrated industries in the country. The simultaneity of auto-related industry growth and economic concentration provided a powerful base for financing, economic expansion and diversification, and stimulation of consumer demand (Bunting 1972; Edwards 1966; Chandler 1966; White 1971).

This unique concatenation of events in US industrialization promoted the ascendency of the automobile sector and its related industries. By the end of the 19th century, the extension of the frontier was completed and the forging of an internal mass consumer market had begun. Primary sector industries (particularly energy and agriculture) experienced intensified productivity, corporate merger waves began, and the induction of cheap immigrant labor permitted the dequalification and homogenization of the industrial workforce.

Nowhere was this combination of work process, industrial organization, and popular consumption more potent than in the automobile industry, where "Fordism" was coined as the model for 20th century industrialization (Aglietta 1979). The scarcity of skilled labor in 19th century America meant that early mechanization replaced complex, craft-dominated operations. In Europe, by contrast, the craft tradition protected autonomy over such skills. This established American tradition of mechanization, along with the availability of unorganized, cheap immigrant labor, permitted the rapid introduction of assembly line techniques. These labor-process changes permitted higher levels of profit, growth, and concentration in the auto industry. Davis (1978:223) precisely describes this process:

> The progressive transformation of the labor process was, of course, closely tied to the emergence of a new sector of consumer durable industries (auto, electrical appliances) at the end of the First World War. This new mass production was, in turn, the outgrowth of the vast centralization of capital accomplished by trust-building financing groups since the turn of the century.

The levels of concentration within the automobile sector (Weiss 1962) and the internal organization of automotive firms with the development of multi-divisional management structures (Chandler 1966) permitted the formulation and execution of corporate strategies expanding and diversifying transportation market control. The socially determined technical improvements in productivity (e.g. the assembly line) furthered marketing changes (style changes, advertising, franchise distribution, and financing). These increased profits, which were invested in horizontally diversified production, eliminated competition from alternative transportation technologies. As Snell (1974) convincingly shows, economic concentration in the automobile industry led to the extension of motorization to the public transit industry. By controlling supply contracts, bus, oil, and rubber manufacturers eliminated the competing electrical transit industry. This hypothesis is confirmed in a study of transit patterns of 31 US cities before and after the rise of the automobile: The changing structure of concentration within the transportation industry resulted in increased spatial dispersion, declining transit ridership, and increased motorization (Yago 1983). Moreover, aggregate data from trade souces comparing costs and profits of motor buses manufactured by the auto industry and electrical streetcars for 1935–1950 indicate that motor buses were consistently the least economical transit vehicles and that their predominance led to the financial and service decline of transit operating firms (St. Clair 1981).

The patterns of economic organizational change within the transportation equipment (bus manufacturers) and transit operating industries parallel political changes in transportation policy and planning. I have already cited historical studies of growing regulation in transit during the period of urban reform and its impact upon centralizing transportation policy in extra-local governmental units. Case studies of inter- and intra-organizational transportation planning conflicts suggest a more recent tendency toward organizational centralization.

Case studies at various levels of government examine the formal organizational changes in units of transportation planning (Davis 1965). The proliferation of governmental units dealing with transportation blocked diversified transportation development (Levin & Abend 1971). The fragmentation of political authority over transportation planning through the establishment of special transportation districts, regional planning authorities, state highway departments, and federal financing policies sedulously centralized planning and subordinated intra-urban travel to inter-metropolitan transportation and suburban-central city commuting (Morehouse 1965; Weber 1974; US Department of Transportation 1976; Mantel 1971). Inter-organizational conflicts in transportation planning among local, regional, and federal governmental units resulted usually in the larger, more centralized unit's dominance. Moreover, the increasing regional, state, and federal power over transportation decisions permitted wide-scale penetration of planning by highway lobby

interests (constructors, highway engineers, auto manufacturers, and trucking companies) (Leavitt 1970).

State and regional planning organizations acted in the 1960s and 1970s to circumvent opposition to highway construction (Cottingham 1973; Fellman 1972), regressively finance transit (Marcuse 1978), maintain or create locational advantages within the metropolitan region through dominating route planning (Adler 1980), and control overall transportation development in the face of changing economic structural conditions (e.g. the energy crisis) and conflicting proposals from opposing groups (Whitt 1982; Yago 1980).

A growing body of evidence in organizational studies, urban political economy, and urban history indicates that historically derived institutional processes in the economic and political organization of transportation appear to affect its relationship to urban growth. The timing, industrial composition, internal class relations, and economic concentration of transportation industries appear to affect transportation's form and function in metropolitan regions. Similarly, the timing, content, and structure of the institutionalization of governmental intervention in transportation planning and policy establish the balance of public and private transportation in the urban system.

THE SOCIAL CONSEQUENCES OF TRANSPORTATION: ENERGY AND LAND USE, DISTRIBUTIONAL IMPACTS, AND SOCIAL INTERACTION

Energy and Land Use

The prolonged energy crisis that began in 1973 has reshaped policy research interest in transportation by focusing it upon the relationship among population, employment, spatial structure, the mix of transportation modes, and energy usage. United States per capita energy use is about double that of other advanced industrial nations (Stobaugh & Yergin 1979), largely because of the high level of energy use in transportation (Pisarski & Deterra 1975). According to the National Transportation Policy Study Commission (1979), 26% of all energy used is in transportation, 40% of all transportation energy is consumed by urban passengers, and 70% of all petroleum energy used is consumed in transportation.

This energy dimension of transportation in an era of cost inflation is reflected in rapidly rising transit costs as a proportion of personal expenditures (Pisarski 1980; Fuller 1981). As decentralization of urban activity and deconcentration of population both within metropolitan areas and between metropolitan and nonmetropolitan areas continue, travel times and distances remain problematic (National Personal Transportation Survey 1977).

Though much has been written in recent years about the links among

transportation, land use, and energy use, we still lack systematic consideration of the variety of social, economic, and demographic factors that condition the way transportation affects energy and land use. Important trends in population distribution between and within metropolitan regions, residential location, and household formation and composition all affect the impact of transportation upon land and energy use, yet these factors have been left largely unexplored. Hypothetical cost models of energy use by various transportation modes and abstract models of land use changes have not provided reliable estimates that may be used in regional planning or the construction of theoretical models of transportation's role in the urban system.

Many of the findings about population size and densities in urban ecological research have been incorporated into studies of urban form and their impact on travel requirements within urban and regional space. As residential, commercial, and industrial decentralization have increased, travel patterns have become more diffuse and less constrained by a few radial corridors leading to the central business district. Monocentric cities are being supplanted by polycentric land-use patterns.

Several studies indicate that travel requirements are reduced in polycentric urban regions. However, transit systems have been criticized as slow to adjust to these spatial changes (Schneider 1981:30–31). Simulation models of energy and travel requirements have been developed to specify variations between metropolitan and nonmetropolitan regional forms (Kydes, Sandborn & Carrol 1976; Peskin & Schafer 1977; Rice 1975). These studies have been unanimous in their conclusion that travel requirements are lowest for polycentric land-use structures. However, the results are based upon several restrictive assumptions of land-use models that allocate residences close to workplaces, while the trend in recent decades has been towards an increasing distance between residence and workplace.

Only Rice (1975) uses actual data for six urban centers—a small number from which to generalize regional and urban patterns. As Schneider (1981:36) notes about these studies, "it is not known how well these conclusions drawn from abstract forms or from extreme departures from an actual situation would hold when applied to a variety of diverse urban regions." Sociological research is needed that will allow us to delineate on the basis of population, transportation, employment, and urban organizational trends the various linkages among metropolitan forms, travel requirements, and energy use.

Researchers have begun to address the issue of total energy requirements of urban and regional metropolitan regions affected directly and indirectly by transportation. Heretofore, energy transportation studies have been largely confined to vehicular energy intensity (Congressional Budget Office 1977; Nutter 1978). The hypothetical cost models upon which these studies are based have many methodological flaws. The basic problems with these studies are that (*a*) they assume fixed population densities as the basis of projected

ridership, thereby ignoring studies showing the impact of transportation development upon land-use patterns; (*b*) they extrapolate current ridership loads into the future to show the expense of rail systems, while ignoring possibilities of increased ridership; (*c*) construction costs for rail rights of way are included while those for buses are not, making construction-cost comparisons unequivalent and invalid; (*d*) they use profit maximization rather than productivity criteria in comparing modes; and (*e*) they compare two or more modes within a particular travel market.

Revisions of these studies in light of the methodological criticisms mentioned above (Sydec 1979; McShane, Bloch & Ihlo 1981; Pushkarev 1980) have examined operating systems to determine the difference in efficiency between transportation based on electricity and that based on liquid fuel.

Pushkarev (1980:126) has also looked at indirect consumption by all transportation. Using input-output data he found that indirect consumption in maintenance, wayside, and construction adds about 40% to the gross cost of fuel used for vehicle operation. Examining total gross energy costs, he is able to specify conditions under which energy efficiencies may be maximized by various highway transportation modes.

Although these refinements direct transportation research to consider both the direct energy costs of transportation and its indirect costs in infrastructural construction and industrial and household energy consumption, we still lack research applying these notions within the context of a variety of urban and regional structures in a concrete data set. Thus energy research in transportation is still largely suggestive and requires further research linkages to the demographic, organizational, and institutional processes of transportation change indicated by earlier research.

Distributional Impacts of Transportation

Advances in transportation technology make more information, goods, services, educational and employment opportunities, land, recreation, and so forth available to those with access to transportation. The unequal distribution of that access on the basis of race, sex, income, and class has been the focus of a growing body of transportation research. Since the McCone Commission first noted the impact of rail transit abandonments upon the Watts Riot in Los Angeles, the issue of the distribution of access to transportation within metropolitan regions has been raised periodically, suggesting the distributional impacts of physical mobility upon social mobility.

With the increased decentralization of workplace locations and the concentration of low-income, underemployed residents in the inner city, a mismatch developed between the location of the urban poor and that of their employment opportunities (Kain 1968). Intra-metropolitan changes in job locations, increasing residential segregation by income, race, and class, deficiencies in public transit, and lower rates of car ownership exacerbate employment prob-

lems of the urban poor, both working and unemployed. Population and employment distributions in metropolitan regions create distance barriers maintained through separate and unequal transportation services (Mooney 1969; Ornati 1968; Davies & Albaum 1972).

Similar inaccessibility of transportation due to low levels of transit service and lack of automobile ownership have been documented for women (Lansing & Hendricks 1967; Ericksen 1977; Madden & White 1978; Lopata 1980) and for the elderly and handicapped (National Survey of Transportation for Handicapped People 1978; Paaswell & Berechman 1976).

Among those with access to urban transportation, inequities appear in time spent in work-related travel. Although shifts in transportation technology towards private transportation and policies supporting that trend promised the universal destruction of the barriers of space through decreased travel time, they created instead land-use patterns that imposed new spatial limits to mobility. Average time required to travel to work has remained about the same since World War II in spite of faster cars. In urban centers more dependent upon the automobile than upon public transportation, the average travel time to work has increased (Voorhees & Bellomo 1970:121–35; Guest 1975:220–25) and will probably increase 10–15% by the end of the century (OTA 1979:26). Moreover, work trip length varies with an individual's position in the social structure: minority and blue-collar workers travel farther and longer to work than the average worker, regardless of residential location (Greytak 1970; Feldman 1977).

Inequities result not only from inaccessibilities of urban transportation, from the structure of job and residential locations in the metropolitan region, and from the distance and duration of work-related travel but also from the pricing and subsidy policies of local, state, and federal transportation agencies. Subsidies for highway development, free parking, and commuter rail services create incentives for suburbanization and increased highway travel volumes (Wachs 1981:243–51). In public transit, flat-rate pricing policies force short-distance, off-peak users to pay disproportionately high fares, offsetting losses incurred by the system in serving long-haul, peak-hour travelers. Those supporting transit operating deficits through sales, property, and income taxes are also negatively affected by fare and subsidy policies. A recent study of pricing inequities discovered current fare practices have a regressive redistributive effect especially among minorities, women, and those without cars (Cervero, et al, 1980).

Social Interaction

Less tangible, but no less real, are the effects of transportation upon everyday life. Research in this area is at best cursory, only suggesting the social psychological dimension of urban transportation. Comments on how trans-

portation affects social interaction in the family and community must therefore remain speculative.

Time-budget surveys have provided insight into the variability of time spent in work-related travel. Work-related travel has been shown in both cross-national and inter-metropolitan comparative studies to vary with the means of transportation used, the distance traveled, the size and density of the urban agglomeration, and the traffic capacity, speed, and geographical layout of travel corridors (Javeau 1972; Szalai 1972).

As travel time increases, time spent in familial interaction, especially child-rearing activities, decreases. This may influence both affective relations within the family (e.g. marital stress or divorce) and learning behavior among children (Lansing & Hendricks 1967).

As part of the environment and a key mediator between that environment and the individual, urban transportation can affect and be affected by its users' desires for autonomy and control. Urban travelers favor transportation systems that serve these desires (Brunner 1966:100). As part of the urban environment, tranportation contributes to the set of props relevant to the individual's social role. Consequently, transportation congestion, overcrowding, subway breakdowns, and the like may create a dehumanizing environment that erodes the urban dweller's sense of identity (Bateman & Brown 1968; Tehan & Wachs 1972).

Transportation-related stress—tension generated by declining transit service, increased traffic noise, highway traffic congestion, transit overcrowding, and increased travel time—may contribute to the "psychic overload" suggested by Milgram (1970). Subjects exposed to transportation-related stress appear in at least one study (Korte & Grant 1980) to adopt social behavior that is either undesirable (e.g. lack of helpfulness) or inappropriate (e.g. aggression); such behavior may indicate a reduced awareness of peripheral environmental stimuli and a heightened sensitivity to traffic-related frustration. Moreover, increased travel time, overcrowding, and exposure to traffic noise are believed to affect stress-related physical disorders (Lundberg 1976).

Though much research on the social psychological dimensions of urban transportation remains to be done, evidence suggests that the way urban space is usually partitioned today may have resulted in the social isolation of the workplace from community life, the "invisibility" of the elderly and the young, and the erosion of social cohesion in neighborhoods. Today, community interests appear to be perceived as separate from workplace concerns; the primacy of private over public life weakens political participation; and the socialization of children in isolation from diverse income, age, and social groups weakens the sense of belonging to a broad community. Motorization and transportation-related changes appear to have narrowed the diversity of

urban experience, separating communities and workplaces and insulating urban travelers from the world in-between.

CONCLUSIONS

This review suggests many areas in which transportation research can continue to be an important area of sociological inquiry. In recent years, the prevalence of spatial and technological determinism in studying transportation impacts and change has given way to subtler and more informed considerations of the historical and institutional context of spatial and techological processes. Distinguishing variables and hypotheses from diverse theoretical perspectives will allow future research to clarify more about urban change. Neither human ecology, urban political economy, locational theory, nor social psychological theory can claim exclusive understanding of how transportation affects urban life. Further theoretical and empirical synthesis should specify both the social structural and spatial limits of transportation and urban form.

The missing links in this synthesis of the ecological, institutional, and individual impacts of transportation provide abundant research opportunities. What changes in urban political and economic organization (local and regional government, markets, corporate structures) promote spatially centralizing or decentralizing tendencies? How can macro-social historical comparisons of urban policy clarify the variations in social and spatial structural interactions affecting transportation? How can we introduce organizational and ecological variables into our assessments the impact of policy changes on land use, energy use (both direct and indirect), and inequalities of access? What is the link between physical mobility and social mobility in the urban region? How can we assess the impacts of transportation upon social interaction in order to improve the accounting of social costs in policy decisions? Which management structures (centralized or decentralized) best promote transportation effectiveness in the urban region?

Emerging out of past gaps in transportation research is an exciting research agenda that could increase our basic understanding of social and technological processes. Study of transportation could help us better to link our theoretical understanding of spatial/social structural changes with the policies designed to plan them.

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