Relationships among jobs, housing, and transportation are much in the news recently. Suburbanization of employment is seen as straining the limited transportation facilities and services available there. Lack of affordable housing in reasonable proximity to employment centers is claimed to be causing lengthening commutes, at least for moderate-income households. Yet proposals to invest in new highways are challenged on the grounds that they might only serve to fuel another round of suburbanization and inner-city abandonment. Each argument has its counterarguments, fueling debate and contention.

Jobs, housing, and transportation interrelationships increasingly are on the minds of transportation researchers and practitioners, as well. This is a departure from earlier stances: for many years most transportation agencies took the position that transportation was put in place to serve development, and agency officials liked to say that they were not in the land use business. Although the point always could have been argued on effect if not on intent, today it is increasingly challenged from both perspectives. Transportation investments are sought to revitalize the central city, spur rural development, support economic growth and competitiveness, reduce environmental degradation, and improve social equity. If transportation agencies have
not been in the land use business, today many would argue that they should be.

Transportation investments are seen by many as instruments for the shaping of metropolitan structure and, indeed, for the transformation of metropolitan living. Rail transit proponents hope that major capital investments in a new round of rail projects will redirect urban growth patterns toward more compact, centered development. Proponents of new highways argue that economic development will be supported by the investments. Advocates of advanced highway technologies tend to focus more on congestion relief and safety benefits, but if the hoped-for order-of-magnitude increases in speeds and capacities are indeed attained, local, regional, and interregional land use impacts could be massive.

Although some seek to structure land use through strategic transportation investments, others seek to use land use planning techniques such as urban limit lines and urban density requirements to restructure the urban area and reduce or redirect the demand for transportation. At the smaller scale of urban design, a better matching of transportation to the specific land uses it serves is advocated. Design objectives aim for transit-oriented and pedestrian-friendly environments, with closer attention to street layouts and street widths, to sidewalks and bike facilities, and to planning for a balance of housing, jobs, and services.

Hopes that wise transportation investments and coordinated transportation–land use planning could improve the quality of life are matched by fears that transportation also could cause great, possibly irreparable, harm. Transportation’s role as a major source of air pollution is a case in point: an emerging question is, Will transportation investments alleviate pollution problems by reducing congestion and smoothing out flows, or will they ultimately lead to higher emissions by stimulating land uses and changes in travel behavior that would offset any gains? That investments and policies will cater to the desires of the affluent and leave the urban less-advantaged behind is also a grave concern for many.

How, and to what extent, can transportation be expected to shape locational choices and support improved opportunities for jobs, housing, and other goods and services? To what extent can better coordination of transportation and land use improve overall performance? Can transportation’s social and environmental impacts be tamed and redirected without recourse to its land use impacts? Theory and empirical evidence provide some insights but also raise a number of additional questions deserving of research.
This paper provides a brief review of the issues. It begins with a discussion of transportation—land use theory, focusing on residential and business location choice. It then summarizes key findings of empirical studies on the land use and urban development impacts of transit and highways. Land use planning approaches intended to moderate and redirect transportation demand are then discussed, along with urban design approaches. The paper concludes with a discussion of methodological concerns and research needs.

BASIC RELATIONSHIPS

Land use—transportation interactions have been the subject of a long tradition of inquiry, and a strong framework for the understanding of key relationships has emerged. Economic theories of location and land use are dominant, but sociological and historical theories also offer insights.

Location Theory

More than a century and a half ago, von Thünen (1) and Ricardo (2) observed that land, labor, and capital are the primary inputs of production and that the use of land is determined, in part, by its location. The location of transportation facilities and transportation technology determines the relative location, or accessibility, of places. Thus, land values as well as land uses reflect the relative locational advantages transportation systems confer.

Von Thünen (1) and Dunn (3), among others, dealt with agricultural land uses; Isard (4), Wingo (5), and Alonso (6), among others, dealt with the urban case. Kain (7), Mills (8), Anas (9), and others have extended and elaborated on the basic approaches. All of this group of models are rooted in land economics and in the concepts of optimality and equilibrium in land allocation.

In simple form, consider a center at which production and distribution activities are concentrated. Transportation costs increase with distance from the center, and in determining the amount to bid for land at a particular location, the bidder takes the transportation costs into account. All else being equal, location at the center minimizes transportation costs; land values therefore are highest at the center, and other locations will command lower rents reflective of their greater costs of transport.

But not all land uses would gain equally from a central location. If transportation is ubiquitous, a central location maximizes access to
suppliers and to markets. Specialization is best supported by such a location, which also offers greater opportunities for economies of agglomeration and economies of scale than do less centrally situated sites. Activities that are specialized, that can capture the economies that central places make possible, or that need regular face-to-face contact with other firms, can minimize their costs by locating close together in central locations. They thus outbid others for space there.

Ancillary firms that provide goods and services to these central offices also need good access to the center but require less face-to-face contact (and probably have a lower-salaried work force, with lower values of time). Hence they will locate near, but not at the center. Other activities with less frequent need for central access bid less and locate further out. Housing is one such activity, because access to the center is primarily needed for employment. A balance is reached with particular uses characteristically found in central places, others in successive rings farther out.

The theory postulates a clear causality: Accessibility determines the worth of land for different uses at different locations. If transportation costs are changed, the rent gradients change; because land uses and rents for land are tied to each other by market processes, land use potentials are changed.

Applying this theory, investments that lower the cost of transportation to an employment center should simultaneously reduce the value of land at the center and increase the value at the periphery. Reduced commuting costs (or times, because time has value) would make it possible for commuters to spend more on housing, to travel farther, or both. If, as is usually the case, transportation is cheap relative to housing and one can buy more house per dollar farther from the center, households will have an incentive to live farther away from their work places. All else being equal, then, investments in transportation are likely to decrease residential density and increase the size of the urbanized area.

Applying similar reasoning, an increase in real income also would have a decentralizing effect. Population growth, on the other hand, would tend both to increase density in the center (because of greater competition for a fixed amount of land) and cause outward growth, as demand spilled over.

**Business Location Theory**

Business location theory, although developed along somewhat different paths, also rests on concepts of economic evaluation of transpor-
tation and other costs. Although some businesses are tied to particular sites because of needs for special qualities only available there, others can choose where to locate within an urban area by considering the relative costs and benefits of doing business at a particular place. Transportation is one such cost; businesses need access to goods and markets, and their labor costs reflect commuting costs. If transportation costs are reduced at a particular place, businesses there will be more profitable and better able to expand; other businesses also will find the location comparatively advantageous and seek to locate there. Thus, in theory, businesses will tend to congregate at points where transportation costs are low.

Population-serving businesses, which sell frequently purchased goods and services, are a special case, because their competitive edge depends in large part on their convenience to residences. If residences decentralize, these businesses follow, decentralizing this portion of the work force as well. The specific location of these businesses, however, still depends on the relative costs of transportation to alternative locations. A general reduction in shopping trip costs would permit population-serving firms to locate farther from residences and still be convenient to customers. Put another way, firms could attract customers from a wider area and still benefit from lower transport costs for inputs. In so doing, they might be able to lower costs, expand offerings, or both, and perhaps capture economies of scale and out-compete firms in less advantageous locations.

Overall, business location theory says that transportation improvements will tend, simultaneously, to increase employment at benefited sites and to decentralize workers' housing. Conversely, worsening transportation services will favor decentralization of jobs but support higher densities of housing.

Other Theories of Urban Growth

The bid-rent formulation of location theory focuses on economic factors in explaining the spatial distribution of various land uses. Alternative theories put forward by Burgess (10), Hurd (11), Hoyt (12), and others place greater emphasis on historical and social factors and cycles of growth and decline. Industries once located near the waterfront to use water transport and the water itself; their activities attracted workingmen’s housing but repelled many other uses. The wealthier classes originally built houses near the center of the city, but as those houses grew obsolete, chose to build new ones in outlying areas made accessible by new transportation systems. Their
old houses filtered down to less affluent classes. Durability of build-
ings and infrastructure, along with patterns of blocks and ownership of parcels, retarded change in land uses by making land assembly, consolidation, and clearance difficult and expensive. Economies of scale in building made new construction cheaper on vacant land, and this further spurred suburbanization, quite apart from land rents.

Harris and Ullman's (13) work identified still additional factors affecting development, including the need for specialized facilities and services (transportation and other), agglomerations that support mutual profitability, forced clustering of nuisances, and constraints working against alternative housing location choices (lack of money, class segregation). In this conception of urban growth, different activities would locate in distinct nuclei, or subcenters, because of the interplay of these factors. Transportation would exert a different influence over location in the various nuclei because of different, specialized needs of the occupants. Berry's (14) work has emphasized specialization of places and the growth of hierarchies of places, with both historical factors and agglomeration economies playing a role.

**Limitations of Available Theories**

Both location theories and alternative theories on land use–transportation interactions provide useful insights but are limited by restrictive assumptions and partial specifications of causal factors. Historical-sociological theories have been largely descriptive, with few attempts to extend them to formal prediction. Economic approaches, in contrast, have attempted to support forecasting; however, critics point to the limited number of factors explicitly considered and note the restrictive assumptions on which the basic analytic models are based, particularly in their highly abstracted mathematical forms.

Monocentricity of employment is perhaps the most widely criticized assumption, but other assumptions, including treatment of households as having only one worker, simplified treatments of topological and temporal variations, and the assumed dominance of market forces (that is, the exclusion of legal, institutional, and social constraints), also are recognized limitations of this class of models. Several authors present detailed reviews and critiques, including Alcaly (15) and Giuliano (16).

These limitations complicate and condition the lessons of the simple bid-rent model of location and land use but hardly invalidate them. As extended by researchers in the 1960s, 1970s, and 1980s, the theory itself is broad enough to encompass multiple centers; indeed, such
centers would be expected to form as population moves outward, certain businesses follow markets, and others seek a supply of labor or cheap land on which to spread out. Agglomeration economies and specialization of places in a hierarchy or system of cities help explain the number of subcenters, whereas their location would perhaps be predictable as a function of relative accessibility, land availability, and other factors. The problem with these models is perhaps less a conceptual one than that mathematical tractability declines with each additional dose of reality.

**Recent Models of Location and Transport Choice Processes**

Adding realistic detail such as urban and suburban subcenters and multiworker households, and accounting for other important factors such as land availability, building quality, and the effects of social class, race, and local government services, requires simulation rather than analytic models. The results of such efforts generally support the relationships of transportation investments to land use and urban form postulated by location theory but also show that many other variables, including cost and suitability of land and buildings, labor market conditions, available services, social factors, and, for households, life-style and life-cycle considerations, are also critical factors in location choice.

Models developed by Lowry (17), Putman (18), Ducca and Putman (19), Herbert and Stevens (20), Prastacos (21), and others represent attempts to develop practical analysis and forecasting techniques for use in urban land use and transportation planning [see Hamburg et al. (22), Berechman and Small (23), and Bajpai (24) for reviews of the state of practice]. In general terms, these models allocate jobs and housing within a region as functions of accessibility, land availability, population and employment by category, income (for households), and other factors. Such models, although complicated and expensive, typically make several simplifying assumptions not wholly in accord with theory. At the same time, they typically overcome some of the limitations of pure analytical approaches; for example, travel times and costs can vary in different parts of the region and other spatial and socioeconomic heterogeneities can be entered into the assessment. Although in many applications this class of models has only moderate predictive capability, model applications nevertheless indicate the importance of transportation level of service to location decisions.

Other model developers have attempted to develop a stronger behavioral justification for location decisions. Prime examples are logit
models of households' location and transportation choices [e.g., Lerman (25), Anas (9), among others]. These models typically include, in addition to land use and transportation accessibility variables, detailed household socioeconomic and life-style descriptors (including the number of workers present, household income, age of household members, presence of children, etc.). The studies confirm that transportation time and expense variables do matter—decisions on the location of jobs and housing do reflect concerns about transport costs. Other things being equal, congestion is associated with a preference for housing closer to work; long commutes are supported by better transport facilities.

For the most part, however, these models show that transport variables are no more critical to location decisions than such factors as housing type, size, and cost suitability, crime rates, and, for families with children, schools. Moreover life-style and life-cycle variations have been found to be equally important as (in some cases, much more important than) transportation as determinants of location and land use choices.

**EMPIRICAL STUDIES AND ISSUES**

Given such complexities, can theorized land use and transportation relationships, or those implied by model results, be discerned in the real world? A number of studies have investigated various aspects of the interactions, particularly focusing on the effects of transportation investments on land use, location, and economic development. These studies have used a variety of methodologies, including macroeconomic investigations, econometric analyses, and input-output modeling of national and regional effects. Before-after studies of specific facilities or regions and survey-based research on residential and industrial location choices also have been used.

Many of these empirical studies suffer from methodological and other limitations (lack of explanatory power for observed correlations, difficulty in distinguishing cause and effect, failure to distinguish economic shifts within a region from investment-induced growth, double counting of benefits). Few have been scoped broadly enough to identify possible shifts in production processes and changes in economic and social organization that might occur as a result of important new transportation investments. Nevertheless, the studies offer insights. Overall, they find that transportation availability and quality are factors in location and development, but investments—at
least, the modest investments typical of today’s transportation programs—will do relatively little absent other critical factors including appropriate land, labor, and capital.

**Land Development Effects of Highways**

Studies of the land development effects of highway investments have a long and detailed history (26–31). Recent studies have been motivated in large part by the interest in using highways as instruments of economic development. However, most studies have found that highway investments are but one factor in a larger growth and development equation (32). Some studies have failed to find an impact of any sort, especially in areas with weak markets for development; others have found that highway investments allow pent-up demand for new development to be released. Many of the studies that have attributed “growth” to a new highway have failed to account for the likelihood that growth would have occurred elsewhere in the region had the highway not been developed. A shift, not an increase, is what has occurred (33).

Environmentalists sometimes argue that it is precisely this shift that is of concern, in particular if development is induced by transportation improvements to make more trips, make longer trips, or relocate from high-density areas where many trips would be made by foot or transit to low-density areas heavily dependent on the automobile. Newman and Kenworthy (34) claim that international data on transportation, land use, and energy consumption establish a strong basis for this concern; among metropolitan planning organizations, scenario-testing exercises and a few modeling efforts using real data have explored this issue sufficiently to support the conclusion that shifts could occur sufficient to offset at least some of transportation investments’ initial travel benefits. [See Frank (35), among others, for a review of the literature on the transportation, environmental, and other consequences of alternative development patterns; see Harvey (36) for a discussion of the modeling issues.]

But the magnitude of the effect remains unclear, and controversy continues over when and to what degree a highway improvement will induce trips, shift modes, and alter destination choices. It seems likely that more detailed consideration of this issue will be required in coming years (36, 37).
Land Development Effects of Transit

Can transit investments alter development patterns? Here, the question of shifts is central, because many look to transit to help restructure development into more compact, efficient patterns. Most studies have focused on rail systems, though a few have looked at less place-specific investments such as trolleys on shared right-of-way and bus services (38-43).

The results of the studies are mixed (44-46). Many localized benefits can be found, but from a regional perspective the benefits are quite modest. Shifts toward compact growth and increased density, when they occur, seem overwhelmed by stronger regional trends toward decentralization. Rail systems do seem to have supported additional downtown development, though several also apparently made once-remote suburban locations sufficiently accessible to spur development at the fringe (39, 47).

Overall, the findings on transit are similar to those on highways. Transit availability and quality affect location and land use, but so do many other factors. Unless these other factors are supportive, transit investment will not make a difference in development.

LAND USE AND URBAN DESIGN INTERVENTIONS

So far, the discussion of land use and transportation has focused on location decision processes as a function of transportation and land costs, or on transportation impacts on land use patterns and mixes. The work in these areas draws heavily on an economic conception of urban spatial processes. Most theories of transportation and land use, and most models based on those theories, assume that market forces dominate; they pay little attention to explicit planning and policy interventions, public or private. And when these interventions have been considered by economists, the reaction has been almost entirely negative. Indeed, zoning and other interventions into the operation of land markets have been roundly criticized for artificially restricting development, especially the development of housing for low- and moderate-income households; land regulations have been blamed for higher housing costs and longer commutes.

Yet a variety of planning and policy interventions are being considered as means of improving the management of transportation-land use interactions. Among the interventions receiving the most attention are state and regional planning and programming approaches; creative zoning and other land use regulations (including those tech-
niques collectively called “growth management”), public and private site design regulations, financing and pricing policies, and intergovernmental relations (48–51).

Many of these measures are being proposed specifically as means of reducing transportation problems. The most common methods include

- Urban limit lines and urban development reserves designed to produce compact development in areas where urban services are already available or are scheduled;
- Mandatory consistency between local land use plans and local and regional transportation plans;
- Requirements for the provision of adequate public facilities concurrent with development, or attainment of minimum level-of-service standards;
- Mandatory balancing of job growth with housing development, priced and located to match the needs and incomes of the work force;
- Minimum as well as maximum development densities and floor-area ratios to ensure adequate development for transit to work;
- Incentives and bonuses for desired land uses and for developments that provide desired transportation and land use amenities; and
- Site design planning emphasizing pedestrian access and transit serviceability.

Advocates of these techniques believe that they would produce both transportation and land use benefits. Urban limit lines would focus development and encourage efficient use of land; infrastructure costs would be reduced. Joint planning and development of land uses and transportation facilities would avoid many conflicts and capacity problems. Explicit planning for alternatives to the automobile would create supportive environments for their operation and use; improved positioning of work, shopping, educational, recreational, and other facilities relative to residences would reduce trip lengths and make walking and bicycling feasible. In some cases, intensive trip-generating land uses would be concentrated so that high-capacity transit could be deployed successfully; major highway improvements would be foregone and parking restricted to make the automobile less attractive.

Advantages to society overall are thought to include decreased requirements for travel, lower energy consumption, and less air pollution; urban sprawl would be reduced, sparing valued agricultural lands and other open space. Costs also would accrue, but they have re-
received less attention. Theory says that these strategies would tend to favor central locations over other ones, and perhaps raise housing prices in the most accessible locations. In some cases, development would be likely to spill beyond the urban boundaries into unregulated, rural towns, or perhaps would shift to other metropolitan regions.

Empirical evidence on the regionally oriented measures is accumulating (52) but remains too scattered and partial for effective use by policymakers; here is clearly an area for future research. At the smaller scale of urban design, recent projects have attempted to moderate travel demand and influence mode choice through a conscious design process. Assessments of these projects have identified four key underlying dimensions: density, development size, land use mix, and design features (scale, coverage, etc.) have been found to be of use in explaining observed differences in travel patterns, with the first three appearing to be most important (53, 54). Abundant free parking also has been found to be a critical factor in mode choice, favoring drive-alone (55). Yet the variability with other factors—real estate markets, location within the region, demographics, and lifestyle—is substantial and only partially understood. More work will be needed on the stability and replicability of the partial results found to date.

**OTHER POLICY AND INSTITUTIONAL ISSUES**

Although land use policies have received the most attention, financing and pricing policies also affect transportation and land development in ways both obvious and not so obvious.

Fiscal zoning—zoning in tax ratables and zoning out housing, especially housing for families with children—has become as notorious as it is ubiquitous, though few concrete proposals on how to deter or offset the effects of this practice have been suggested. Regional tax sharing and fair-share housing programs are the strategies most often mentioned, but their acceptability and efficacy, respectively, are in doubt. How fiscal zoning affects transportation, especially the commute to job-rich, housing-restricted suburbs, is only beginning to be explored; early results suggest that low- and moderate-income households may face substantially longer commutes than would be the case in a less restrictive locale.

Other products of the local government fiscal crisis may have a more positive effect: exactions and impact fees may provide the re-
sources to improve transportation conditions. Yet studies suggest that optimism may be misplaced, because impact fees often are a fraction of what would be needed to offset traffic growth or provide meaningful alternatives, and their imposition may worsen housing costs and direct development to fringe/rural areas where growth is relatively unregulated and welcomed.

Tax policies are a third area affecting transportation, land development, and locational patterns. Tax deductions are believed to lead to artificially high levels of consumption of housing; parking exemptions support overconsumption of automobile travel; depreciation rules (along with banking and insurance deregulation) helped support office overbuilding in the 1980s and the subsequent competition for tenants in a soft market. And taxation and pricing of transportation itself, from fuel taxes to toll road policies, have land use as well as transportation implications.

Finally, intergovernmental relations can have a major impact on land use and transportation issues. Currently, land use is predominantly a local government issue; transportation is a shared responsibility of federal and state governments and special districts in which local cities and towns usually play but a minor role. Competition and conflict, with attendant negative spillovers, have led to initiatives in states such as Florida and New Jersey to build new institutional relationships fostering coordination, cooperation, and negotiation. It remains to be seen whether such new governmental arrangements will produce improved outcomes, or whether greater advantages result from the Tiebout (56) world in which fragmentation of local government allows individuals to "vote with their feet" and match government services to their own tastes.

**CONCLUSIONS: AREAS FOR FUTURE RESEARCH**

The relationships among transportation, land use, and urban form have been much studied, and important conclusions can be drawn from this large body of research. Nevertheless, many questions remain, and there is a need especially for careful attention to matters of method and data, as well as a need for additional research.

**Methodological Issues**

Several methodological issues become apparent in reviewing theory and evidence about land use—transportation interactions and contrast-
ing what is known or can be analyzed with the policy issues being raised. To start, further elaborations of theoretical models to account explicitly for multinucleation, specialization of places, spatial irregularities, and nonhomogeneous tastes are needed. Such efforts are under way, but more attention and more resources are needed.

Perhaps most notable from an empirical viewpoint is that the issues are not well addressed by most operational land use and transportation models in use today. Theory says that changes in the availability and level of service offered by transportation facilities would affect location choice, trip generation, destination choice, and mode choice. Operational models for the most part lack the recursiveness needed to assess the extent to which such feedback would occur. In this respect they lag behind the state of the art and may even represent regression from earlier periods in which planning and analysis commanded greater attention and resources. In any case, procedures for estimating the effects of transportation on development patterns are needed, as are empirical studies to be used as an evidentiary base.

A related issue concerns data. Without good data, sound analysis results cannot be expected. Yet data problems have hampered most of the studies reported in the literature, and data problems may have worsened since those studies were done. A new round of travel surveying, traffic counting, and other investigations is overdue in most metropolitan areas. Moreover, if serious analyses of transportation—land use interactions are to be carried out, at least some of the data needed must be longitudinal, permitting the analyst to track changes over time. This is particularly true for studies of growth effects that may occur over a 10- to 15-year period.

**Research Needs**

Questions about how transportation shapes locational choices and supports improved opportunity have moved to the forefront in recent years, along with concerns about potentially negative impacts of transportation investment on air quality and sprawl. Proposals to use transportation to spur economic growth and revitalization, reduce environmental degradation, improve social equity, and increase the quality of the built environment are key policy agenda items. Theory provides useful insights into the likely effects of these policy proposals but is increasingly unable to capture the effects of important changes in structure resulting from economic, social, demographic, and technological change. Empirical work suggests that transportation’s role
can be important, but better information on the precise nature and magnitude of the effects is needed.

Promising research topics include the following:

- Development and refinement of both conceptual and analytical models of location that account for multinucleation and specialization and reflect demographic and socioeconomic realities;
- Development and refinement of modeling approaches for analyzing land use–transportation interactions, including feedback effects of transportation supply on location and trip making;
- Application of improved theories and models to explore the likely impacts of a variety of transportation and land use policies, including new technologies and alternative public policies;
- Both quantitative and qualitative exploration of the transportation impacts of alternative zoning, growth management, and other land regulation strategies;
- Analysis of the effects of finance and pricing policies on both transportation and land use choices and patterns; and
- Exploration of alternative organizational arrangements and assignments of responsibility and their effects on transportation and land use outcomes.

ACKNOWLEDGMENTS

Development of this paper was supported in part by the University of California Transportation Center. Portions of this paper draw upon a paper written by William Garrison and Elizabeth Deakin for the Institute of Transportation Studies.

REFERENCES

33. D. J. Forkenbrock, T. F. Pogue, N. S. J. Foster, and D. J. Finnegan. Road Investment to Foster Local Economic Development. Iowa University Public Policy Center, Iowa City, May 1990.
47. M. W. Webber. The BART Experience—What Have We Learned? The Public Interest, No. 45 (Fall 1976), pp. 79–108.


