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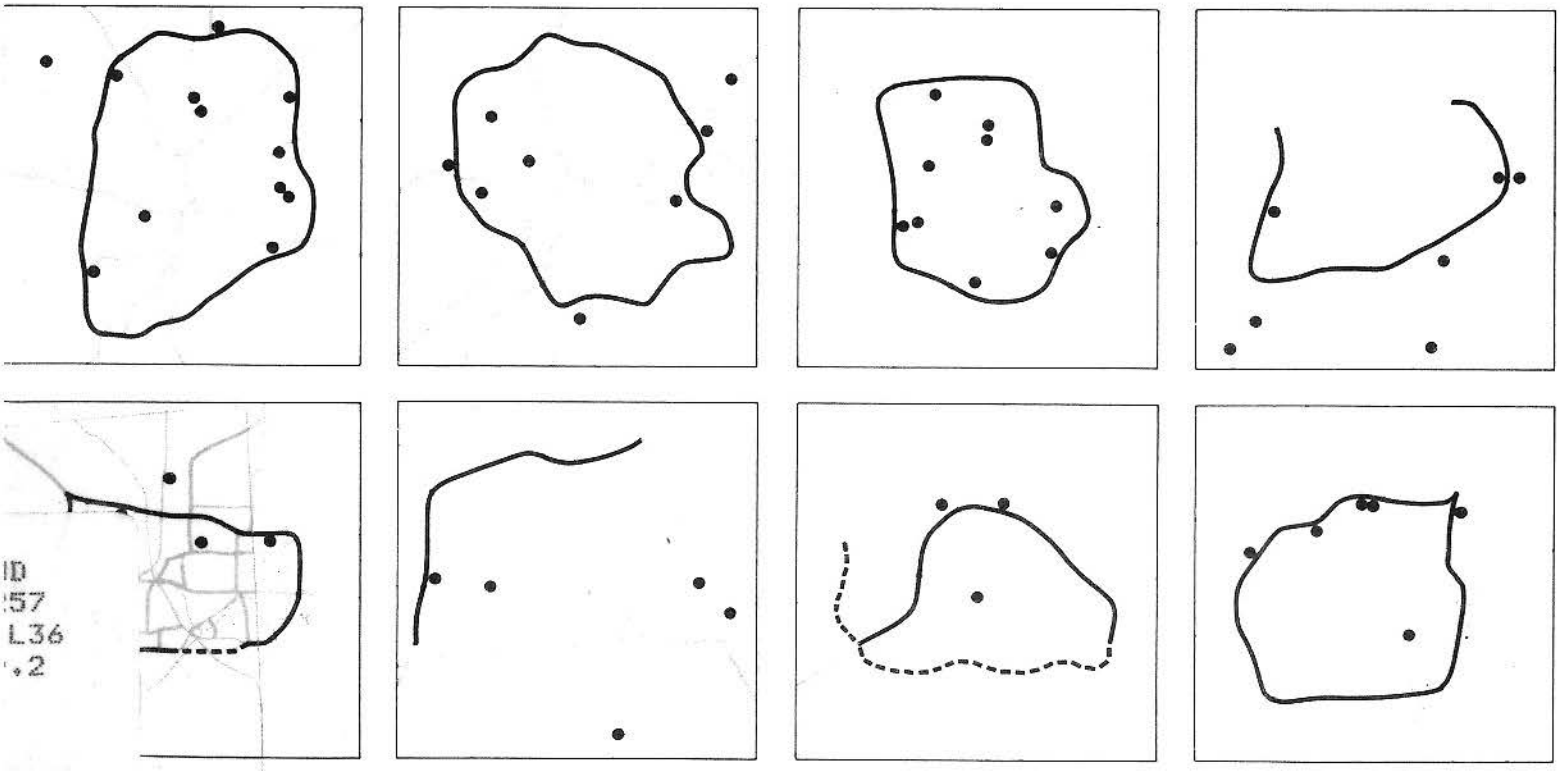
THE LAND USE AND URBAN DEVELOPMENT IMPACTS OF BELTWAYS



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THE LAND USE AND URBAN DEVELOPMENT IMPACTS OF BELTWAYS FINAL REPORT

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for

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STUDY OBJECTIVES AND RESEARCH METHODS

This study, jointly commissioned by the U.S. Department of Transportation and the U.S. Department of Housing and Urban Development, presents an assessment of beltways' land use and urban development impacts and describes the urban and transportation policy implications. Prior research and the findings of a comparative statistical analysis and detailed case studies were examined to determine (1) what effects beltways have had, (2) why beltway-induced changes have occurred, (3) who was affected by such changes, and (4) how federal and local government agencies can work with business and community groups to capitalize upon the potential benefits offered by beltways and to minimize or eliminate their anticipated adverse effects. Of particular concern to the federal government is the possibility that beltways may undermine central city revitalization efforts and attempts to achieve compact, energy-conserving and environmentally sound land use patterns.

The findings and conclusions of this study should be of interest to and usable by a broad spectrum of individuals and groups, including federal decision makers, local land use and transportation planners, members of business, community and civic organizations, academics, and environmentalists. The study produced four publications on the land use and urban development impacts of beltways, one or more of which may serve the purposes of the reader not interested in the entire research effort. Available are Executive Summary, Case Studies, and Guidebook, as well as this volume, the Final Report.

FINDINGS AND CONCLUSIONS

The study methods relied primarily on prior research, a comparative statistical analysis of 54 metropolitan areas (27 with beltways and 27 without), and eight detailed case studies of the effects of beltways in Atlanta, Baltimore, Columbus, Louisville, Minneapolis-St. Paul, Omaha, Raleigh, and San Antonio. This summary highlights the principal findings and conclusions of each of these approaches to the experience of American beltway cities.

Prior research offers little guidance to those dealing with beltway issues today because the scope of analysis usually was quite limited, alternatives to the beltway rarely were evaluated, analysis methods were not sophisticated, and insufficient time had elapsed for historical trends to evidence much effect potentially attributable to beltways.

The **comparative statistical analysis** shows some statistically significant differences potentially attributable to beltways, but these are neither large nor consistent over time. Further, many "beltway effects" reflect regional differences in urban development and economic vitality. Suburban beltways typically were built in the Northeast around older urban areas, beltways within central cities were constructed in the South and Midwest, and metropolitan areas without beltways usually are in the "Sunbelt". Consequently, beltway cities are larger, less healthy, and have experienced less population growth over the last 20 years than non-beltway cities.

The most important discovery of the statistical analysis is that beltways and beltway attributes, such as length, distance from downtown, interchange spacing, and age are less important than non-beltway factors shaping regional economic growth and the distribution of population, employment, housing, and retail sales.

The **Case Studies** explore the effects of beltways on local land use and transportation planning and capital improvement programming, development decisions, housing and employment opportunities, and central city revitalization efforts. The socio-economic, fiscal, and environmental consequences of beltway construction in each metropolitan area also are assessed. Finally, the case studies include an analysis of measures that enhance the benefits of beltway construction and reduce or eliminate its adverse effects.

Drawing upon the results of each component of the study, the report closes with an assessment of the policy implications of this research. Recommended methods are offered to improve local and regional planning efforts, to evaluate beltway location and interchange spaceing policies, to coordinate transportation planning with planning for other infrastructure investments, to maximize opportunities for compact development and to minimize potential adverse effects of beltway construction on urban revitalization efforts.

This study presents no startling conclusions notable in itself, since so often the debate on new highways is quite polarized. Proponents focus on the transportation benefits and potential development opportunities in the corridors and communities to be served, ignoring or discounting environmental consequences and impacts elsewhere in the region. Critics fear that circumferential highways will draw away commercial development from older commercial centers, including both downtowns and other communities with first generation shopping centers and commercial districts. The evidence is mixed. Where theory, intuition, and local experience in specific instances indicate the ability of beltways to effect the full range of potential impacts, the comparative statistical analysis reveals that beltway construction rarely has significant regional consequences. Case studies have shown that a beltway may be predicted to alter the character of urban growth, but local initiative is required to reduce or eliminate potential adverse impacts of beltway construction on development patterns, on public facilities programming, on central city economic health, on particularly vulnerable segments of the population, and on the metropolitan environment. Local initiative also can enhance the benefits of beltways.

What is important, and what this report and companion document, the **Guidebook,** do is to address the relationship between new highways and other factors influencing urban development and describe actions which can be taken by local governments, working federal agencies and the private sector, to take advantage of the opportunities and avoid harmful consequences generated by beltway construction. In this sense, the final report can be viewed as an "independent audit" of the nation's experience with beltways. By stressing the urban and transportation policy implications, both federal decision-making and local decision-making may be improved.

1. INTRODUCTION

PURPOSE OF THE STUDY

Beltways—limited access highways partially or completely circling cities—are integral components in many urban transportation systems, but their effects on land use and urban development and the economies of regions and central cities are not well understood. When the Interstate Highway System was planned in the 1940s and 1950s, beltways were viewed mainly as bypass highways, carrying through traffic around central cities. With dramatic, post-war suburbanization of housing and employment, beltways have become important links between suburban centers and subcenters. As such, they have played an increasingly critical role in the movement of people and goods within metropolitan areas and have affected location and development decisions. Research to date has concentrated on impacts on retail and industrial location, but no consistent evidence exists as to beltways' effects on urban form and their socioeconomic, fiscal and environmental implications, though such information is crucial for understanding impacts of previously built beltways and evaluating proposals to construct beltways in approximately 30 metropolitan areas.

The relationship between beltways and other forces shaping our cities also is not well understood. These factors include the nature of the radial highway network, the age and structure of the central city, land availability, real estate market trends, local zoning and land use policy, annexation law, utilities extension policies, and environmental constraints. Of particular interest to the federal government is whether a beltway supports or undermines federally funded programs for urban revitalization by drawing economic activity out of older urban areas. Also important are effects on development patterns as national urban policy seeks to foster efficient, energy-conserving and environmentally-sound land use patterns.

This report presents an assessment of beltways' land use and urban development impacts and describes the urban and transportation policy implications. Evidence from past experience should prove useful in planning and decision-making on proposed beltways and also assist federal and local officials to capitalize on the opportunities beltways offer and to minimize or eliminate potential adverse effects. The study relied primarily on prior research, a comparative statistical analysis of 54 metropolitan areas, and a detailed case studies of eight beltways. The specific methods used are described after the policy issues are presented.

BACKGROUND AND ISSUES

In improving accessibility between points, a beltway (or any new transportation facility) will influence travel behavior and decisions on where to locate. Households desiring a larger house, more land, or a rural environment may find that a new or improved highway allows them to move further from work yet still commute in a reasonable time. Manufacturing and distribution firms seeking sites for expansion or new facilities can find cheaper land at outlying locations which are accessible to suppliers and markets within the metropolitan area and nationwide.

Demand by suburbanizing firms and households may encourage developers to build industrial parks or new housing in areas served by a new beltway or connecting artery. Speculative development also may draw people out to newly accessible areas. Shifts in residential development patterns expand markets for retail goods and services, creating demand for commercial development. If permitted by zoning, this activity may cluster around interchanges, taking advantage of their visibility and accessibility.

Shifts in housing and employment location will affect property prices and real estate market trends and may have socioeconomic, fiscal, environmental, and energy impacts.

Suburbanization of residential and business locations has been underway in this country for many years, particularly in the case of the manufacturing industry. Studies of retail sales patterns between 1954 and 1958 indicated a lack of growth or a decline in central business district (CBD) sales in many metropolitan areas, well before the construction of extensive networks of arterial and beltway freeways in most metropolitan areas. Since 1970, the movement of retail activity to the suburbs has exceeded the same movement of population and purchasing power. In the seventies, CBD retail sales remained stable or declined in constant dollars, and suburban sales increased dramatically.

Most of the land use impacts attributable to highways are transfers within the area, rather than growth. When this is the case, equity becomes the central issue. Who gains and who loses when a highway is built? Clearly those who own land near the new facility will gain if development is allowed. Therefore, those who own land elsewhere where development might have occurred in the absence of the belt will lose an equal amount, although the loss is spread over all property. Retail businesses located near a new highway will draw business from other outlets in the metropolitan area. Residents served by the new facility will gain in accessibility; residents elsewhere also may gain from decreased congestion throughout the highway network. If employment moves to suburban locations in response to a beltway, inner city workers who rely on transit will lose accessibility to employment opportunities.

Discrimination against lower income and minority persons in the suburban housing market adds a socioeconomic dimension to the beltway balance sheet. Because equal opportunity for employment and housing is a major federal objective, a beltway that hampers attainment of this policy must be evaluated carefully to ascertain if its benefits outweigh its potential detrimental effects. In this case, compensating programs to mitigate adverse impacts could be implemented. In other situations, the beltway's negative effects may be sufficiently large to justify alternative solutions for transportation needs.

The impact of a beltway will vary depending on its characteristics and location. Beltways can serve two main functions: (1) divert traffic passing through the area from congested local commute routes, and (2) provide for better distribution of non-CBD oriented trips within the area. The first function entails little land-use effect, except for increased demand for travel-related business. However, diverting through traffic from a strong, vital CBD suffering from congestion could increase accessibility for commuting and shopping trips, though diversion of local trips from a weak CBD could contribute to further decentralization of economic activity.

Transportation Policy Issues

1. **Are beltways essential components of a regional highway system? Will they serve the travel markets for which they were designed better than alternatives?**

Beltways carry both local and through traffic. In some cases, their ability to function as a bypass highway may be affected by high volumes of local traffic and peak-period congestion. Analysis of the design and traffic-carrying capacity of existing beltways may offer important lessons for those planning future beltways. The relation between beltways and the radial highway system also can be critical; and, in this context, interchange spacing may be the key to defining their role in the regional transportation system.

2. **Beltways may relieve congestion on radial highways and local streets. Is there any evidence that they do this more efficiently than alternative transportation improvements?**

By providing new or added capacity in a transportation corridor, a beltway can divert trips from congested highways and local streets. They also may encourage people to make trips that might have been deferred or not made at all because of the accessibility they offer and may attract developers to interchange areas, which in turn may increase traffic on local streets and radial highways, possibly causing greater congestion than would have existed if they had not been built.

3. **Do beltways support or hinder efforts to increase transit ridership and reduce total travel?**

Beltways do not serve travel corridors where most people share the same destination, so efforts to offer transit service on beltways are not likely to meet with much success. In the absence of beltways, urban development patterns may be more radial and thus more easily served by transit. However, opportunities for nodal development around interchanges may make paratransit and ride-sharing programs viable in suburban communities which otherwise might not be able to support local transit service. Beltway interchanges also may provide sites for park-and-ride lots which could be part of a joint development effort. To make such efforts work, local governments and state highway departments may need to know more about success and failures elsewhere.

4. **Are differences in beltways' impacts, both on travel and on land use and urban development, attributable to differences in beltway characteristics: partial versus complete, inner versus outer? Are there threshold effects?**

Conceptually, the integrity of a complete beltway in contrast to a partial circumferential highway has intuitive appeal, but a "balanced" transportation system may not require that the loop be completed. The uneven distribution of travel demand and the tendency of urban areas to grow in some directions but not in others may eliminate the justification for complete beltways in the future unless they are judged as an essential element of a package of incentives to promote compact, energy-efficient, and environmentally sound urban development—the objective of current national urban policy. Differences between inner and outer beltways also are important, particularly when the question of jurisdiction is introduced and shifts in economic activity affect the fiscal resources of a central city. Inner beltways may

economic activity affect the fiscal resources of a central city. Inner beltways may serve both through trips and local trips, while outer beltways may function mainly as by-pass highways with few land use effects.

Urban Policy Issues

1. Do beltways affect the economic and fiscal health of central cities?

If industrial and commercial development clustering around suburban beltway interchanges represents a shift from central city locations, then beltways have an adverse economic and fiscal effect on central cities by depriving them of employment and sales and property tax revenues. Federal support of beltway projects then may conflict with efforts to meet national urban policy objectives.

2. Do beltways affect the demand for other, federally financed infrastructure investments?

By encouraging development in formerly vacant areas, beltways may increase the need for public facilities. These can include interchange improvements, water trunks, sewer trunks and treatment facilities, and other forms of municipal investment. Many of these investments are largely funded from matching federal and state grant programs, thus inducing additional expenditures. The provisions of suburban water and sewer extensions can lead to further scattered suburban residential development and thus contribute to depopulation of central cities. As a consequence, beltways indirectly may improve the competitive position of suburban sites, and thus work against the purpose of the federal assistance to central cities.

3. Do beltways affect the distribution of employment or overall employment growth?

By improving movement of people and goods and providing access to developable land, beltways may have a small positive effect on a metropolitan area's ability to compete economically with other areas. This could increase overall employment, as firms which might have gone elsewhere move to an area because its highway system most clearly meets their needs. Even if beltways have no regional competitive advantage, and consequently no effect on overall employment, they still could affect the distribution of employment within the metropolitan area. For example, developers of regional shopping centers and industrial and office parks might have considered sites closer to the urban core within the jurisdiction of the central city if a suburban beltway had not been built.

4. Does beltway-related industrial and commercial development reduce accessibility to employment opportunity for central city residents, particularly low income and minority?

Employers located along beltways may find it difficult to attract blue collar workers, presumably living in the central city. Because alternative locations may be more accessible to blue collar workers, a beltway could reduce employment opportunities for workers who do not or cannot follow firms to suburban locations. However, by increasing overall metropolitan accessibility, a beltway could increase mobility to employment for many persons, including disadvantaged residents of small communities within the metropolitan area.

5. **Do beltways contribute to scattered suburban development, or do they provide compact, high density development in already suburbanizing areas?**

Beltways may draw activity into subregional centers and focus suburban commercial development around interchanges, rather than increase outlying development within metropolitan areas. The most likely effect of a beltway is probably mixed, encouraging some households to move further out, and thus contribute to scattered residential development, but also to centralize some activity centers in suburban communities, leading to a multi-nodal metropolitan area. In this case, it is important to know how beltways can best be used to achieve compact development patterns.

6. **Do beltways contribute to increased energy consumption by inducing travel or by creating longer trips?**

National policy, while still oriented to increasing mobility, is now stressing the conservation of energy as a key goal. These goals may be contrary. While a beltway or other new transportation facility may increase travel as well as possibly increase average trip length, it also may have the beneficial influence of making some trips more efficient by reducing congestion on the existing highway network.

7. **Do beltways contribute to environmental degradation through increased air pollution, consumption of agricultural land, or disruption of sensitive environments?**

As most existing beltways were built before current environmental legislation had been enacted, probably little attention was given to environmental effects. Current requirements for environmental review should reduce or mitigate adverse impacts of future beltways, but there still remains the possibility that by increasing vehicle miles traveled, a beltway could contribute to increased air pollution, and beltway-induced development may increase conversion of open space and agricultural lands to urban use.

8. **Is beltway-related development compatible with regional and local planning objectives, and are planning tools available to deal with the effects of the beltway?**

Pressure to rezone interchange areas for highly intensive land uses, such as shopping centers, office and industrial parks, and apartment complexes may be affected by completion of a beltway. Such developments often led to traffic congestion in the interchange vicinity as the beltway usually was not planned with such uses anticipated. Further, planning for other required infrastructure improvements such as local streets, sewers, water, and other municipal services may not have anticipated the needs of beltway-related development. Finally, such development could have negative effects on older, established business districts—an issue addressed by the President's 1979 Community Conservation Guidance.

9. **What are the local and metropolitan effects of alternative transportation improvements?**

Alternative solutions to transportation needs, including widening of existing freeways, improving transit and traffic management activities, will have different effects on traffic congestion, energy consumption, the environment, and regional and local development patterns. Although a beltway may have some negative effects, alternatives may cause even greater detrimental effects. A new or widened radial highway, for example, may require the relocation of central city residents, and be more expensive because of increased right-of-way costs. National transportation policy calls for analysis of alternatives to transportation improvements to ensure that such tradeoffs are not ignored.

10. Are there benefits for the metropolitan area as a whole that outweigh detrimental effects on particular jurisdictions?

An important issue is whether, or to what degree, beltways negatively affect central cities. Studies of prior beltways have not been conclusive, but some beltways have contributed to decentralization of economic activity, reducing the tax and employment base of the central city by a small, but not inconsequential, amount. Although this has occurred, are there metropolitan area gains in competitiveness and overall accessibility that compensate for the detrimental effects?

APPROACH

To obtain a comprehensive picture of beltways' impacts on land use and urban development keyed to the policy issues identified early in the study, three distinct research efforts were undertaken. First, all relevant literature was reviewed, including empirical studies on specific beltways and other highway impact studies. This provided a historical and policy background on beltways, setting the research issues in perspective. Then, a comparative analysis of urbanization in 54 cities, 27 with beltways and 27 without, was conducted to ascertain whether there are any significant differences in population or employment growth, retail activity, commuting patterns, or household patterns. This analysis was structured to determine the importance of the beltway relative to other influences affecting growth and urban development patterns. Finally, complementing the comparative analysis was a detailed case study effort, which examined the historical role of beltways in local land use policy and urban development in eight metropolitan areas. These represented the range of conditions present in American cities and the diversity of beltways themselves, including highways of different ages, lengths, distances from downtown, jurisdictional locations, capacities, and traffic volumes. The case study effort focused mainly on the decision history, motivations of key actors, and the role of government and the private sector in shaping the development patterns.

Throughout the study, the policy implications were emphasized so that the results would be useful for those dealing with beltway projects. The principal objective was to provide decision-makers and others involved in land use and transportation with a better understanding of the urban impacts of belt highways and the ways in which the benefits can be maximized and potential adverse effects minimized or eliminated. Particular attention was given to the problem of identifying and isolating effects attributable to a belt highway from those caused by other influences on urban development, the key to which is knowledge of what might have occurred if a beltway had not been built. In most instances, beltway planning studies did not include an analysis of alternatives, so one is forced to turn to other sources for an answer.

Usually, these were local officials or others involved in the development process who could state whether their decisions would have been different in the absence of a beltway.

Times series analysis of "capture" rates and the distribution of economic activity also provided an important perspective on beltways' influence. If the share of new construction, for example, occurring in one area does not change appreciably between pre-beltway and post-beltway time periods, then one can conclude that the beltway has not measurably enhanced the attractiveness of an area for development. However, it may have prevented the area from losing some economic activity to other, more attractive communities.

This study presents no startling conclusions, which in itself is notable because the debate on new highways has been polarized. Proponents focus on the transportation benefits and potential development opportunities in the corridors and communities to be served, ignoring or discounting environmental consequences and impacts elsewhere in the region, particularly on downtown. Critics of circumferential highways fear that they will draw away commercial development from older commercial centers, including both downtowns and other communities with first generation shopping centers and commercial districts. The evidence is mixed, but provides a basis for addressing the relationship between new highways and other factors influencing urban development, and for indicating what actions can be taken to capitalize opportunities and to avoid harmful consequences.

In this sense, the final report can be viewed as an "independent audit" of the nation's experience with beltways. By stressing the urban and transportation policy implications, both federal decision-making and local decision-making may be improved.

USERS OF RESULTS: AUDIENCE ORIENTATION

Although this report focused mainly on experience to date with beltways, findings and conclusions are presented so that they will be useful to those making decisions on new beltways or improvements to existing beltways or on land use and urban development policies directly related to beltways. This audience includes federal, state, regional and local decision makers (both professionals and lay people), policy analysts, researchers, academics, and others interested in how beltways affect land use and urban development.

The analytical procedures and investigative methods also may be potentially applicable to similar policy-oriented research on the effects of transportation investments on urban areas.

PRODUCTS

The findings and conclusions of each component of the study are synthesized in this report. A separate Guidebook contains recommendations for planning and evaluating beltway proposals and for identifying and implementing measures to maximize benefits and to minimize potential adverse effects, particularly on central cities. A Case Studies report is published as a supplemental volume presenting the eight case studies examined in depth to complement the quantitative statistical analysis and the literature review, summarized in this Final Report and the Executive Summary.

2. THEORETICAL, HISTORICAL, AND POLICY PERSPECTIVES

To put the comparative analysis and case study research in a proper context, it is useful to begin with a review of prior research, both theoretical and empirical, and policy documents. How did the concept of an urban beltway originate, and what purpose was it to serve? From a theoretical perspective, what effects are likely to occur? Have these been confirmed by prior research? Did the expectations of those planning beltways match reality? Finally, what policies have governed decisions on beltways at federal, state, and local levels? Each of these questions are addressed in the following sections on theoretical issues, historical and policy issues, research issues, and prior case studies. The chapter closes with an assessment of the implications of work to date for policy-making and planning.

THEORIES OF URBAN DEVELOPMENT

While there is no universally accepted theory of the relationship between transportation facilities, location decisions, and the resulting pattern of urbanization, this subject has been the focus of much study. Empirical and theoretical models of residential location, employment location, and the interactions between them have been proposed and tested.

Residential Location. The basis theory of residential location, as formulated by Alonso (B-1), Wingo (B-20), Kain (B-7), and others, posits a tradeoff between housing costs and journey-to-work costs, the latter including value of travel time as well as out-of-pocket costs.[1] The cost of a unit of housing decreases as the journey to work increases. However, as incomes rise, most households move from the central city to more expensive neighborhoods. This is assumed to reflect a stronger desire to consume more housing rather than to avoid increased transport costs.

Given this widely accepted housing price-transportation cost relationship and an initial assumption that all trips are to a single central business district (CBD) employment center, land rent would decrease proportionally with distance from the center. Recognizing that transportation corridors affect the speed and ease of travel, the relative distance or accessibility from any given point to the center will change with the transportation network. For example, Figure 2-1 illustrates equal travel time lines that theoretically result in a city with two intersecting highways and a rectangular belt highway. The belt decreases transportation costs and improves the accessibility of sites along the loop relative to alternative locations. Consequently, urban development in the beltway corridor should be greater than if the loop had not been built.

Employment Location. Several models address the relationship between employment location and transportation facilities. The classical model was originally formulated by Weber (B-19) and updated by Hoover (B-7), Isard (A-30), and others. This model

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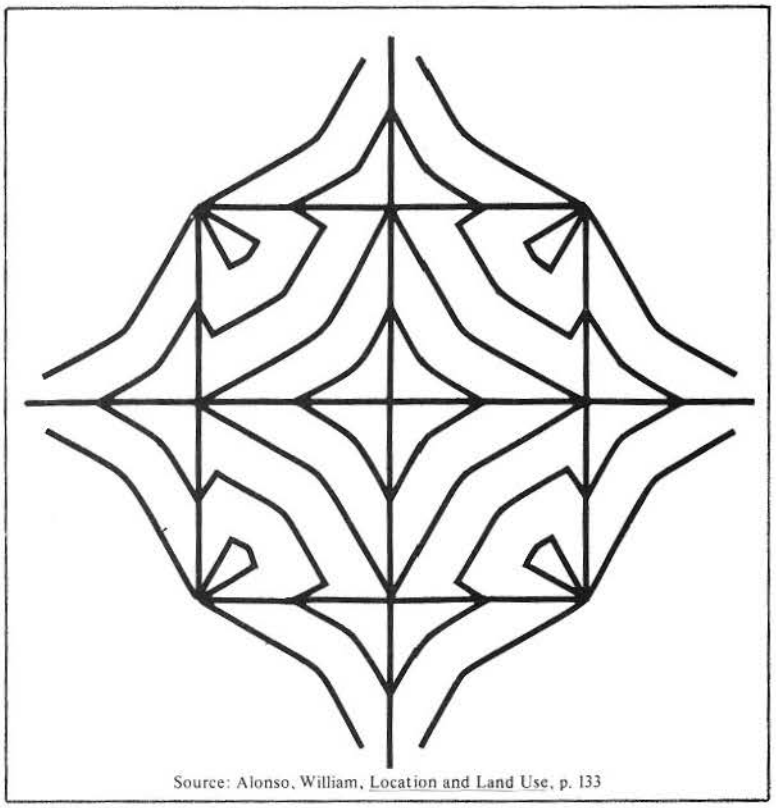
1 To facilitate reference to the annotated bibliography in the Appendix, all citations are numbers with an alpha-numeric code, referring first to the subject area and then to the specific reference.



Source: Alonso, William, Location and Land Use, p. 133

Figure 2.1.
ISOCHRONES ON A RECTANGULAR STREET GRID WITH TWO INTERSECTING HIGHWAYS AND A RECTANGULAR LOOP

postulates that a firm will choose that location which minimizes its total costs of procuring and processing its inputs and of distributing its product to its customers. Each industry has different parameters depending upon the importance and cost of its raw materials, including labor, and the nature of its product and market. Changes in optimum location could result from changes in production technology, prices of inputs, and costs of transportation to its market. Historically, dependence on shipping and railroad transportation for raw materials made central city ports and railroad terminals attractive locations for manufacturing and distribution activities. As transshipment points, such locations often were the lowest cost location for operation. Over time this changed, for reasons well expressed by Kain:

> These trends in industry location are the result of basic changes in production and transportation technologies. Intercity and intracity motor trucks freed most producers from having to crowd into the limited area near deep-water ports or railroad marshaling yards... For an increasing number of firms, outlying locations near major intercity highways and suburban beltways became more advantageous...(In sum, the) principal effect of these changes in freight and communications technologies was to make locations throughout metropolitan areas more

uniform in terms of transportation costs, reducing greatly the former locational advantages of central areas conferred by the concentration of freight and passenger terminals there.[2]

In many production processes, technological innovation has resulted in smaller quantities of raw material per unit of output. As a result, proximity to markets and distribution systems has become more important to locational decisions (B-7, B-12).

Another theory of firm location is based on central place theory developed by Walter Christaller with refinements by William Garrison and Brian Berry (B-2) among others. This theory stresses competition for customers as the determinant of plant or store location, rather than production and distribution differentials. This model clearly is more applicable to retail outlets where the cost of materials and production does not vary markedly within a metropolitan area.

Because different industries and businesses have different densities of demand, a hierarchy of commercial and industrial centers will develop. In retailing, the best example of this is the existence of neighborhood, community, and regional shopping facilities where step increases in market area are required to support each facility respectively.

Changes in transportation networks affect locational decisions and employment densities in two ways. First, reducing transportation cost reduces goods prices. Second, if changes in transportation costs favor one area over another, sales or production in that area will rise relative to other areas because of increased competitive advantage. In this manner, a differential accessibility improvement can shift production, sales, employment, or some other measure of economic activity within the metropolitan area and even between regions if the improvement is substantial (B-9, B-11, A-30, A-38).

While much empirical research has been done on residential location, fewer empirical studies have addressed the role of transportation in employment location. As Kain points out, this stems in part from the lack of suitable, readily available employment data coded by geographic location within metropolitan areas, as compared to the decennial census which provides excellent spatial data for population and housing.[3]

Attempts to link theoretical residential and employment models commonly are called interaction models, the Lowry Model being the best example (G-46). These models deal within the interrelationship of workplace and residence location without assuming fixed central locations for all employment as do residential models, or fixed residential locations as do the employment models. Interactive models simulate actual development by allocating exogenously determined "basic" employment, that is export-based jobs, to geographic subareas. Then assigning residential

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2 Kain, John, "Postwar Changes in Land Use in the American City," in Toward a National Growth Policy (Daniel Moynihan, ed., New York: Basic Books, 1970), p. 75.

3 Kain, John, Essays on Urban Spatial Structure, (Cambridge: Ballinger Publishing Company, 1975), p. 12.

development patterns are predicted by a gravity model assuming minimum commute time. Population-serving employment is then distributed as a function of first-round residential land use allocations. Projected development is constrained by land availability and regional control totals.

Most theories of transportation systems' impact on urban development fall short of replicating actual conditions (G-54). Those theories describe development as more responsive to transportation systems than is possible in the short term. For five to ten years the majority of the housing stock and investment in industrial and commercial buildings represents a bulky and immoveable fixed asset. Only the locations of new development and people moving their workplace or residence will be affected by changes in the transportation network, although the value or price of fixed stock may be affected. Further, factors not considered by most models include real estate market trends, local public policy, as reflected in plans and zoning regulations, topographic and environmental constraints, aesthetic conditions, federal tax policy, discrimination constraining housing choice, and differing levels of public services.

Transportation and Urban Form. There is great debate as to whether urban transportation improvements, including radial freeways, beltways, and mass transit systems, act as the determinants of land use, or whether the opposite is true. Transportation planners and economists have argued that lower density development and suburbanization are the result of increases in income, a consumer preference for additional space, and decreases in the price of commuting. Kain contends that these forces were magnified during the 1950s because mobility and housing development had been limited during World War II.[4] With this perspective, transportation planning becomes the process of forecasting land use and designing the transportation system that best serves the anticipated land use pattern.

An alternative view is that transportation strongly affects land use and, therefore, should be used to further social objectives. Typically, this view is espoused by planners and those who believe that the urban freeway systems have contributed significantly to the decline of central cities. An example of this philosophy was expressed at a 1978 Transportation Research Board conference:

> Government dollars are being requested to improve highways so that companies can leave the city and move to the suburbs. Such a move is energy inefficient, environmentally wrong, and disastrous in terms of racial policy because these moves are segregative.[5]

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4 John Kain, Essays in Urban Spatial Structure, p. 3.

5 Davidoff, Paul, "Effects of the Questions of Equity, Efficiency, and Revitalization of Cities on Transportation Policies," Transportation Research Board Special Report 183, (Washington, D.C. 1978), p. 25.

The Council on Environmental Quality expresses this same opinion:

> The construction of new highways, mass transit lines, sewers, and other infrastructure can have a powerful effect on local land use. For example, most people are familiar with how the Interstate Highway System has speeded up suburban growth in the suburbs.[6]

Clearly, there is a strong relationship between transportation and urban form. Pre-automobile cities tended to have one node or center of activity, the traditional central business district. All streetcar lines led to this location, and one's choice of a residential location was dictated by the location of public transit networks (unless one lived within walking distance of work). New transit lines contributed to areas of new residential development, called "the streetcar suburbs." The automobile and the increased mobility it allowed have contributed to multi-nodal development and to urban sprawl. Multi-nodal development within a large metropolitan region—a centers concept—can contribute to a more efficient form of development in terms of trip distance. In an ideal plan, the nodes are connected with high-speed, high-capacity transportation linkages and have lower level networks connecting the individual nodes to their hinterland. If these nodes are distributed in a pattern surrounding the central core, a circumferential highway or transit link serves this function. Urban sprawl, characterized by a lack of nodes and undifferentiated densities, can only occur with a highly developed, relatively high-speed highway network which reduces the time required for long-distance trips.

In summary, both sides of the debate are probably correct in part. Major transportation investments have been made where growth was anticipated, and growth was accommodated by the resulting facility. Athough it cannot be said that a limited access regional highway network causes urban sprawl or the suburbanization of both residential and employment activity, it is probably correct that it is a necessary condition for large-scale, spread development.

HIGHWAYS IN THE INTERSTATE HIGHWAY SYSTEM

Since authorization of the Interstate Highway System in 1944, the federal transportation planning process has evolved from a classical engineering approach to road-building to an interdisciplinary effort responsive to urban, environmental, fiscal, and energy conerns as well as transportation needs. Today, the decision-making process requires a careful assessment of the impacts of a proposed transportation facility and a systematic look at alternatives. This rigor is of recent origin; decisions to build many of our urban highways were not founded on such comprehensive analysis. Consequently, the adverse effects of past actions will not necessarily accompany future, federally-funded investment in transportation improvements, particularly beltways and many of the remaining, uncompleted and controversial segments of the Interstate System. This perspective should be kept in mind as historical and policy issues relevant to a study of beltways' land use and urban development impacts are addressed in the following sections.

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6 Council on Environmental Quality, The Growth Shapers (Washington, D.C.: May 1976), p. 8.

Evolution of Interstate Highway System

The Federal-Aid Highway System in urban areas includes urban circumferential highways as well as limited access beltways built as part of the Interstate System. The policy of federal aid to urban highways, providing impetus for their construction, began with the National Industrial Recovery Act of 1933. For the first time, federal funds could be spent on urban streets that were extensions of the Federal-Aid Highway System to and through municipalities and on "secondary and feeder roads."[7] This recognition of urban highway needs by the federal government was a major policy change from former federal-aid highway programs. Previously, the federal-aid program applied only to rural roads, "excluding every street and road in a place having a population, as shown by the latest available federal census, of two thousand five hundred or more."[8] However, the Interregional Highway Report (IHR) of 1944 concluded that in improving the highway facilities for interregional transportation, there was little need for bypasses and that highway routes penetrating into the cities would exert tremendous influence in shaping city growth.

Federal legislation immediately followed the report. The Federal-Aid Highway Act of 1944 included, among other provisions, generous support for principal secondary and feeder roads (local city/rural roads) and required that $150 million be spent on a system of such roads selected by state highway departments in cooperation with county supervisors or other appropriate local road officials.[9] Importantly, it authorized a Federal-Aid Highway System in urban areas (where originally the routes were extensions of Federal secondary routes or rural Federal-Aid routes) and the designation of a National System of Interstate Highways (following the route location recommendations of the IHR) limited to 40,000 miles, of which 2,300 miles were reserved for urban circumferential routes to be located later.

The 1944 Act and its appropriations led to a boom of urban highway construction immediately following World War II. In 1947, state highway departments, in cooperation with large cities and urban counties, launched a series of "expressway" projects in cities nationwide. New York City, Detroit, Chicago, Denver, Fort Worth, Los Angeles, Miami, San Francisco, and Pittsburgh all began urban highway projects of significant dimensions.

The route locations of the Interstate Highway System were not finalized until September, 1955. Planning criteria for route location included service to cities and rural population, to manufacturing and agricultural production, to concentrations of motor-vehicle ownership and traffic, and to national defense. Additionally, in urban

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7 U.S. Department of Transportation, Federal Highway Administration, America's Highways, 1776-1976 (Washington, D.C., 1976), p. 545.

8 Ibid., p. 175.

9 58 U.S. Stat. 838.

areas the need for through and circumferential routes and their relation to land use, urban planning, and civil defense were to be analyzed.[10]

> Circumferential and Distributorship Routes. Routes which avoid the business centers of cities are needed to serve traffic bound to or from points other than the center of the city. Such routes may be so located as to serve both as arteries for through traffic around the city between various approach highways and as distribution routes for the movement of traffic with local origins and destinations to and from the various quarters of the city. The pattern of such routes depends upon the topography and plan of each particular city. At many of the relatively large cities the need is for routes completely encircling the city. In some of the larger cities a belt route near the central business district may be needed in addition to an outer circumferential route.[11]

In most cases, proposed circumferential highway routes were made a part of the Interstate System, but Federal-Aid funds for urban highways authorized during the next ten years, 1946-56, fell far short of meeting total system development requirements and a 50:50 matching ratio was an inadequate incentive.[12] The landmark Federal-Aid Highway Act of 1956 remedied the funding problem and also broke with tradition and created new principles regarding Federal assistance to a national highway network. Besides providing fundings via the establishment of the Highway Trust Fund, the Act required that "the state highway departments, in planning a Federal-Aid project (Interstate or ABC) involving the bypassing of or going through a city or town, must hold, or offer to hold, a public hearing and must consider the economic effects of such a location."[13] As a consequence, specific route locations decisions for circumferential highways were made by state highway officials with required input from land use and urban planning interests—as well as from the local citizenry, via the public meeting.

To date, partial or complete circumferential highways have been constructed in 35-40 cities. A representative but not exhaustive list is shown in Table 2.1. Twenty-seven of the cities have limited access beltways that are included in the Interstate Highway System.

Typical of the limited access beltways that were not built originally as part of the Interstate Highway System are Route 128 around Boston (I-495, Boston's outer beltway, was constructed with Interstate funds), the Watterson Expressway around Louisville, Kentucky, U.S. 1 and 64 around Raleigh, North Carolina, State Route 289 around Lubbock, Texas, and portions of Loop 410 around San Antonio, Texas.

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10 U.S. Department of Transportation, Highways, p. 469.

11 Commissioner of the Bureau of Public Roads, "Criteria for Selection of Interstate System Routes" (Washington: Report for the Senate Subcommittee on Roads, April 15, 1955).

12 U.S. Department of Transportation, op. cit.

13 70 U.S. Stat. 374.

TABLE 2.1. CITIES WITH BELTWAYS

Atlanta, GA	Lexington, KY*	Raleigh, NC*
Baltimore, MD	Louisville, KY	Rochester, NY
Boston, MA*	Lubbock, TX*	St. Louis, MO
Buffalo, NY	Memphis, TN	San Antonio, TX
Cincinatti, OH	Milwaukee, WI	Sioux Falls, ND
Cleveland, OH	Minneapolis/St. Paul, MN	Toledo, OH
Columbia, MO	Montgomery, AL*	Tulsa, OK
Columbus, OH	Nashville, TN*	Washington, DC
Dallas/Fort Worth, TX	Oklahoma City, OK	Wichita, KN
Denver, CO	Omaha, NB	Winston-Salem, SC*
Houston, TX	Philadelphia, PA	
Indianapolis, IN	Quad Cities, IO/IL	

*Not in the Interstate Highway System.
Source: Blayney-Dyett, from state highway maps.

Circumferential, unlimited access highways include Route 152, a boulevard around Montgomery, Alabama, the Briley Parkway around the eastern side of Nashville, Tennessee, and the Silas Creek Parkway south and west of Winston-Salem, North Carolina.

Planning Requirements. Federal highway planning requirements were first mandated by 1962 legislation (P.L. 87-866). The 1970 Federal-Aid Highway Act (P.L. 91-605) expanded the scope of this activity but still retained a highway orientation, rather than a multi-modal approach to transportation planning. The "3C" process, a continuing comprehensive planning effort cooperatively carried out with the states, was re-affirmed.

The next major legislative milestone was the Federal-Aid Highway Act of 1978 which significantly changed the focus of urban transportation planning. These amendments, clearly distinguished from earlier planning requirements in the following quotation, impose a substantive obligation to tie transportation planning to land use planning, and to recognize the socio-economic, environmental and energy implications of specific actions and solutions to transportation problems. Specifically, Section 134(a) of Title 23 now states:

> It is declared to be in the national interest to encourage and promote the development of transportation systems embracing various modes of transportation in a manner that will serve the States and local communities efficiently and effectively. To accomplish this objective, the Secretary shall cooperate with State and local officials in the development of *transportation plans and programs which are formulated on the basis of transportation needs with due consideration to comprehensive long-range land use plans, development objectives, and overall social, economic, environmental, system performance, and energy conservation goals and objectives*, and with due consideration to their probable effect on the future development of urban areas of more than fifty thousand population. *The planning process shall include an analysis of alternative*

> *transportation system management and investment strategies to make more efficient use of existing transportation facilities. The process shall consider all modes of transportation and shall be continuing, cooperative, and comprehensive to the degree appropriate based on the complexity of the transportation problems...* No highway project may be constructed in any urban area of fifty thousand population or more unless the responsible public officials of such urban area in which the project is located have been consulted and their views considered with respect to the corridor, the location, and design of the project.[14]

Since 1969, the National Environmental Policy Act (NEPA) has imposed similar assessment procedures, including alternatives analysis, but these have not always been well-integrated into system- or corridor-level transportation planning. Typically, planning studies have been exempt from federal environment clearance procedures, so NEPA requirements were not addressed.

Project Review Requirements. In the late 1960s, concern about socio-economic and environmental impacts of highway projects led to enactment of review requirements quite similar to those governing urban planning efforts. The 1970 amendments to Section 109 of Title 23 required the Secretary of Transportation to:

> Promulgate guidelines designed to assure that possible adverse economic, social, and environmental effects relating to any proposed project on any Federal-aid system have been fully considered in developing such project, and that the final decisions on the project are made in the best overall public interest, taking into consideration the need for fast, safe, and efficient transportation, public services, and the costs of eliminating or minimizing such adverse effects the following:
>
> (1) air, noise, and water pollution;
> (2) destruction or disruption of man-made and natural resources, aesthetic values, community cohesion and the availability of public facilities and services;
> (3) adverse employment effects, and tax and property value losses;
> (4) injurious displacement of people, businesses and farms; and
> (5) disruption of desirable community and regional growth.
>
> Such guidelines shall apply to all proposed projects with respect to which plans, specifications, and estimates are approved by the Secretary after the issuance of such guidelines.[15]

Prior to this legislation, reports of the costs and benefits directly or indirectly attributable to highway projects mainly had been prepared to meet the mandate of the Highway Revenue Act of 1956 (70 Stat. 374) in which Section 210 called for such investigations as a basis for imposing taxes and apportioning costs among various users. Section 210 is notably silent on the question of indirect social costs, such as

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14 23 U.S.C. 134(a), italics indicate 1978 amendments made by P.L. 95-599.

15 23 U.S.C. 109(h).

the adverse effects of beltways on central cities. The only indirect effects to be studied are benefits; adverse impacts were ignored.

The NEPA and related legislation enacted in 1969 and 1970 sought to bring more information on the implications of federal actions into the decision-making process.[16] The 1970 Section 109 requirements clearly brought the issue of adverse effects into the project review process.

BELTWAYS AS A FEDERAL POLICY ISSUE

In the late-1970s beltways as part of the Interstate System have come under increasing scrutiny as local officials question their need as transportation facilities and their potential effects on urban areas, particularly on core areas and downtown revitalization efforts. In Dayton, Ohio, Richmond, Virginia, Rochester, New York, Danbury, Connecticut, and Seattle, Washington, local officials have questioned the merits of beltway proposals and similar highway projects in outlying areas. In response to these concerns, as well as studies of trends affecting metropolitan areas and their residents and the impacts of federal policies and programs on cities and regions, proponents of beltways now are being asked to demonstrate consistency with national urban and transportation policies.

The President's 1978 National Urban Policy Report presented the core ingredients of a national urban policy: ten principles and nine policy objectives. Subsequent executive orders, the 1979 Environmental Message, and memoranda from the President have clarified and expanded on key aspects of national urban policy to achieve greater interagency coordination and to focus infrastructure programs, particularly in the transportation sector, on urban policy objectives. Further initiatives are described in the 1980 National Urban Policy Report. Essentially, these evidence a commitment to distressed communities, equal opportunity and economic mobility, and the creation of efficient, energy-conserving and environmentally-sound land use patterns.

Actions to support urban economies include analysis of the "inadvertent negative impacts of federal actions on the economic vitality of distressed communities," as required by the President's 1979 Community Conservation Guidance. Initially focusing on the potential negative effects that a major commercial development, such as a regional shopping center, could have on older commercial centers, the guidelines will be amended to include federally financed investments such as beltways that could stimulate development of industrial and office parks as well.[17]

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16 See Federal Highway Adminstration Notice N6640.17, dated July 16, 1976 for a summary of relevant environmental legislation, available from the Office of Environmental Policy.

17 U.S. Department of Housing and Urban Development, 1980 National Urban Policy Report Executive Summary (draft), p. 56.

Where it can be demonstrated that a beltway might facilitate commercial or industrial development that, in turn, could harm older urban areas or jeopardize the success of inner-city revitalization efforts, compensating or mitigating measures should be implemented to reduce or eliminate the adverse effects wherever feasible. Such measures could include growth management and planning strategies, economic development efforts, and transportation improvements designed to ensure access to core areas.

Building a beltway may hamper federal and local efforts to attain these policy objectives. Trade-offs may have to be made, but proponents should be aware of these policy conflicts. In the sections which follow, the potential conflicts under each policy objective are highlighted.

Urban Policy 1. Strengthen Urban Economies. A beltway may enhance the attractiveness of corridors for industrial or regional shopping center development and thus attract private capital which otherwise might have remained or been reinvested in the central city. However, employers' decisions to leave a central city may be unaffected by the existence of a beltway. Only after the decision to leave has been made would an employer begin looking for sites, and then those looking for sites might consider locations within the same metropolitan area along with locations elsewhere in the nation. In midwestern and northern cities, a beltway may enhance the attractiveness of the metropolitan area and thus keep firms from relocating to southern or western states. Nonetheless, the beltway may represent an incentive to private development outside central cities that needs to be complemented by concurrently offering incentives to downtown development and revitalization.

Urban Policy 2. Expand for Opportunities and Job Mobility. As a beltway affects the locational decisions of employers looking for new space, it also affects the distribution of employment opportunities. As firms move out of the central city, they make it increasingly difficult to provide employment opportunities for the hard-core unemployed and the disadvantaged. This potential conflict has to be viewed in a historical perspective, recognizing the evolution of the central city and the suburbanization of manufacturing and retail employment.

Urban Policy 3. Promote Fiscal Stability. To the extent that a beltway can exacerbate fiscal distress in central cities by drawing off economic activities which otherwise would contribute to a local tax base as property taxes or retail sales taxes, the beltway will make it more costly to provide needed relief. Construction of a beltway may weaken rather than strengthen central city fiscal vitality. However, if the metropolitan area at large gains from beltway construction, a tax base sharing program could be implemented to provide for the needed redistribution of locally-generated revenues.

Urban Policy 4. Expand Opportunity for Those Disadvantaged by Discrimination and Low Income. Within metropolitan areas the history of racial segregation has been well-documented. In a recently completed HUD study, black suburbanization was found to have increased in the 1970s over the rates of the 1960s and 1950s.[18] In fact, in 14 of the 19 metropolitan areas studied, this has resulted in net black out-migration from the central city. In seven of these cities, black moving patterns are approaching those of white households, but in the majority of the cities (12 of 19), black moving rates remain significantly below white moving rates and have shown little increase since 1970. A beltway will increase accessibility for suburban residents and may even link low income and scattered black suburban communities with employment centers, but it is unlikely to increase access for central city minorities to jobs or housing. Consequently, a beltway cannot be viewed a priori as supporting attainment of this objective, except when it links minority residences with major employment centers.

Urban Policy 5. Encourage Energy-Efficient and Environmentally-Sound Urban Development. The conflict between urban policy and a beltway's impacts is obvious if it can be demonstrated that a beltway fosters scattered suburban development and if the resulting pattern can be shown to be energy-inefficient or environmentally unsound. One study suggested that beltways may be drawing economic activity from the hinterland — rural portions of Functional Economic Areas — and not from the central city.[19] If this is true, then beltways may represent a means of providing for urban infill within suburban communities, and containing development within an urban limit line. To accomplish this, strong planning and land use regulations are essential.

National Transportation Policy

In an August 1979 memorandum to the Secretary of Transportation, the President identified six objectives for national transportation policy. To improve the urban transportation decision-making process, the department is to ensure that:

- Federal transportation funds are used to promote energy conservation, for example through special lanes for car pools, van pools, and transit vehicles;

- Encouragement is given to using federal funds for public transportation projects;

- A careful review is made of any transportation proposal which would encourage urban sprawl (a major cause of high energy consumption) or which would tend to draw jobs away from urban centers;

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18 U.S. Department of Housing and Urban Development, Recent Suburbanization of Blacks, (Washington: Office of Policy Development and Research, 1979).

19 U.S. Department of Transportation, Suburbanization and Beltways, (Washington: 1972, an unpublished report).

- Consideration is given to improving and rehabilitating existing facilities, or using non-construction methods—such as better traffic management—to improve transportation systems, as alternatives to constructing new facilities;

- Major transportation projects are used to help improve the urban economy and to attract jobs to the urban cores;

- Firm actions are taken to mitigate adverse effects of transportation projects on the natural and urban environment and to carry out the environmental commitments that are made in planning and approving transportation projects.[20]

Using these as guidelines, the key to securing approval of a beltway will lie in a demonstration that it will not conflict with central city revitalization, increase energy consumption, foster sprawl, or have adverse effects on housing stock and neighborhoods. To achieve this, a comprehensive alternatives analysis is essential.

RELEVANT RESEARCH AND PRIOR CASE STUDIES

Overview

Since the 1950s, numerous case studies have addressed the impacts of interstate highways on urban growth and development patterns, ranging in scope from regional studies to corridor studies of effects on adjacent property values. Nearly all concluded that radial highways and beltways affected urban land use, though the magnitude and extent of impact is found to vary greatly. Many of the early impact studies, particularly of radial highways, examined effects within narrowly-defined geographic bands and treated changes assumed to be related to highway construction as a net gain to the city or metropolitan area. However, much of the gains assumed to result from freeway construction represented transfers from areas not enjoying the increased accessibility and visibility of a new transportation facility. These beltway studies include a more comprehensive definition of the impact area, but employ an analytical approach, which leaves the critical reader somewhat sceptical about the validity of their conclusions.

The next section presents the principal findings and conclusions of major studies of beltway effects, organized by impact category. Following the review of the beltway studies is a summary of major radial highway impact studies and their relation to the beltway impact process.

Beltway Case Studies

Eight major studies of beltway impacts have been conducted (see Table 2.2). The reports vary significantly in scope of analysis, time frame of analysis, and size of

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20 Transportation Policy: Memorandum for the Secretary of Transportation from the President, August 2, 1979, Administration of Jimmy Carter, 1979 (Washington: U.S. Government Printing Office, 1979), pp. 1383-1384.

TABLE 2.2. BELTWAY IMPACT STUDIES

Author	Title	Client	Publication Date
Bone, A.J., Massachusetts Institute of Technology (MIT)	Economic Impact Study of Massachusetts Route 128 (Boston SMSA)	Massachusetts Department of Public Works and Bureau of Public Roads	1958
Thompson, R., Adkins, W. and Davis, D., Texas Transportation Institute (TTI)	Preliminary Study of the Economic Impact of a Section of San Antonio's Loop 13 Expressway	Bureau of Public Roads	1960
University of Virginia Bureau of Population and Economic Research, Julia Connelly	The Socio-Economic Impact of the Capital Beltway on Northern Virginia (Washington D.C. SMSA I-495)	Virginia Department of Highways Bureau of Public Roads	1968
Wilbur Smith and Associates	Maryland Capital Beltway Impact Study (Washington SMSA and Maryland Counties I-495)	Maryland State Roads Commission Bureau of Public Roads	1968
Federal Highway Administration	Suburbanization and Beltways (general study)	—	1972 (Interim Report)
deLeon, Peter and Enns, John, The Rand Corporation	The Impact of Highways Upon Metropolitan Dispersion: St. Louis	National Science Foundation	1973
Khasnabis, Snehamay and Babcock, Willard-North Carolina University	Impact of a Beltline Type of Freeway Upon a Medium-Size Urban Area in North Carolina (Raleigh U.S. Highway 64)	North Carolina Department of Transportation Federal Highway Administration	1975
Muller, T., Neels, K., Tilney, J., Dawson, G., Urban Institute	The Impact of Beltways on Central Business Districts: A Case Study of Richmond (Virginia I-295)	City of Richmond, Virginia	1978

area studied. The Appendix contains a detailed critique of each study, highlights of which are summarized in this section. With the exception of the Wilbur Smith study of the Washington, D.C., beltway, the analyses of beltways in Boston, Raleigh, Richmond, and St. Louis, were conducted by faculty and staff of university or university-affiliated research institutes. The Urban Institute study is unique in that it was commissioned by the City of Richmond, rather than sponsored by a single purpose agency. Also, this study evaluated the potential impacts of a proposed beltway, rather than those attributable to a completed beltway. Finally, the Federal Highway Administration (FHWA) study is not area-specific, but compares growth trends between a set of beltway and non-beltway metropolitan areas.

The metropolitan areas studied ranged in size from Raleigh, North Carolina, with a 1976 city population of 137,000, to Washington, D.C. and Boston, among the largest metropolitan areas in the nation. Characteristic of each study area is the high proportion of the labor force employed in government. Richmond, Raleigh, and Boston are state capitals; San Antonio includes a large military population; and federal government employment in Washington has grown dramatically since 1960. Excluding Raleigh, five of the six central cities suffer from severe physical and economic deterioration and meet HUD's basic eligibility standards for Urban Development Action Grants.

Objectives. The previous beltway studies have diverse objectives, audience orientations, and conclusions. Some address micro-scale effects, land use changes directly adjacent to a new beltway, while others are macro-scale studies, dealing with regional effects. Table 2.3 summarizes the several objectives of the beltway studies.

> **San Antonio:** The original objectives of the Loop 13 study were threefold: (1) to ascertain changes in land values and in use attributable to the Loop, (2) to determine the attitudes of residents and businessmen about the expressway, and (3) to determine the travel characteristics of residents of neighborhoods in the vicinity of the Loop. Because the freeway was not opened until after the study was completed, the objective was modified to be a "descriptive economic study of the selected section of Loop 13."[21]
>
> **Capital Beltway - Northern Virginia:** "The purpose of the study is to investigate and assess the impact of the Capital Beltway on social and economic life of Northern Virginia." More specifically, the study sought to:
>
> - assess the extent to which changes in population, land use, real estate activity, and traffic volumes can be attributed to the Capital Beltway;
>
> - investigate the impact of the Beltway on industrial location and commuting and shopping patterns; and

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21 Thompson, R., W. Adkins, and D. Davis, Preliminary Study of the Economic Impact of San Antonio's Loop 13 Expressway, pp. 1-2.

TABLE 2.3. OBJECTIVES OF BELTWAY STUDIES

Objectives	MIT (Boston)	TTI (San Antonio)	University of Virginia (Capital Beltway)	Wilbur Smith (Capital Beltway)	Federal Highway Administration	deLeon/Enns (St. Louis)	Khasnabis/Babcock (Raleigh)	Urban Institute (Richmond)
Analyze Corridor Changes Attributable to the beltway:								
— Residential land use	●	●	●	●		●		
— Industrial/commercial land use	●		●	●		●	●	●
— Property values	●	●	●	●				
— Travel patterns and traffic	●	●	●	●		●	●	●
Prepare local public policy guidelines			●			●		
Formulate corridor-scale assessment model						●		
Analyze Impacts on the Metropolitan Area:								
— Land use and development patterns	●		●	●	●	●	●	
— Central city vitality	●							●
Formulate metropolitan assessment model				●		●		●
Prepare areawide public policy guidelines			●					

- study how the Beltway has influenced decisions made by local officials, realtors, and businessmen.[22]

Raleigh Beltway: The specific goals of this research were:

- to evaluate the impact of a beltline freeway upon the land uses, traffic, and general environment of a medium-size urban area in North Carolina;

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22 University of Virginia, The Socio-Economic Impact of the Capital Beltway on Northern Virginia, p. 1.

- to develop predictive models to be used by highway planners to assess the long-range impact of a proposed highway upon the land development potentials of the urban area; and

- to contribute to the development of a series of procedural guidelines to enable the planner to better understand the impact of the freeway upon the total urban environment.[23]

Richmond Beltway: The major objective of this work is to determine whether the development of I-295, a beltway proposed for Richmond, Virginia, would adversely impact the Richmond central business district.[24]

St. Louis Beltway: In this paper the authors "attempt to examine the relationship between highway improvement and changes in urban form in the St. Louis Standard Metropolitan Statistical Area."[25]

FHWA Study of Suburbanization and Beltways: "The purpose of the study is to test the hypotheses that beltways are associated with metropolitan growth."[26]

The corridor studies, focusing on narrow questions and smaller areas, were more likely to uncover specific effects, although in most cases real benefits and net gains were confused with transfers of activity. The metropolitan-scale studies are of greater federal and regional interest because of the policy issues they address. However, lack of good data and supporting theory limits the usefulness of their findings.

For the most part, beltway studies have been oriented to four audiences: the academic community, mostly economists and transportation planners; state and federal highway engineers and planners; local planners and policy makers; and federal policy makers. The FHWA and Urban Institute studies clearly emphasize federal policy questions, although the Urban Institute study was intended for local policy makers as well. Early studies, such as these conducted by TTI and MIT, are written for the highway community, including engineers, and some academics, while the two Capital Beltway studies address the concerns of highway engineers and local planners.

Few of these studies explicitly examined federal policy questions, since official concern about the effects of federal highway programs on urbanization patterns

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23 Khasnabis/Babcock, Impact of a Beltline Type of Freeway Upon a Medium-size Urban Area in North Carolina (Raleigh U.S. Highway 64), p. 3.

24 Urban Institute, The Impact of Beltways on Central Business Districts: A Case Study of Richmond (Virginia I 295), p. iii.

25 deLeon/Enns, The Impact of Highways Upon Metropolitan Dispersion: St. Louis, p. 2.

26 Federal Highway Administration, Suburbanization and Beltways, p. 1.

became widespread only in recent years. Today, the issue is whether beltways affect intra-metropolitan growth patterns, particularly the flow of jobs and retail activity from central cities to suburban communities. While there can be no simple answers to these questions, there are several specific concerns about beltways requiring closer analysis. These include potential beltway effects on the fiscal health of central cities, accessibility of employment opportunities, local and regional land use planning, energy consumption, and the environment.

Methodology. The beltway studies can be grouped into two analytical categories: those that compared population growth or retail sales patterns in beltway and non-beltway metropolitan areas and those that examined the effects of a particular beltway. The comparative studies used secondary statistical data to examine population or retail sales trends in central business districts and central cities as a proportion of metropolitan area totals. The several limitations of this method should be recognized, including inadequate sample size, few tests of statistical significance, and no correction for variance in overall growth rates.

The other studies employed several analytical techniques:

- Geographically based time series trend studies of population, housing, land value, employment;

- Predictive regression models of land use changes in relation to interchange and overall metropolitan accessibility;

- Attitudinal surveys of residents, workers, and representatives of firms locating near beltways; and

- Analyses of changes in traffic patterns.

Impacts on the value of property adjacent to the beltway were addressed in the two MIT, TTI studies, while a third combined accessibility models and regression analysis to project population effects with and without the beltway. This approach is noteworthy as the only attempt to evaluate what would have occurred in the absence of the beltway, but the alternative considered was the no-project alternative; a different transportation investment would have been a more helpful comparison.

Impacts on housing and employment growth were evaluated by comparing pre-beltway trends with post-beltway trends and by interpreting surveys of movers and firm managers. Survey sample sizes generally were adequate but the questions on the importance of the beltway were limited in scope. Respondents were not asked whether they would have located where they did without the beltway or why they left their former location. No emphasis was given to those who moved from central cites, older suburbs, or from other metropolitan areas, and the only net employment gains appeared to result only from hiring by firms that moved to a particular metropolitan area partially on account of a beltway. Several of the analyses focus on industrial location decisions affected by beltways, but do not determine where the firms would have located in the absence of the beltway. The St. Louis study was unique in that it examined the effects of the entire freeway network, rather than limiting its analysis to either beltway or radial links. In none of the studies was there any analysis or even speculation as to whether beltways' impact on the decentralization of industrial or retail employment differed from that attributable to radial highways.

To evaluate beltway impacts on travel behavior, three studies used interviews, origin-destination studies, and statistical models. Beltway trips were not stratified to distinguish new trips, extended trips, or trips formerly made on other routes or to alternative destinations. While many aspects of these studies suffer from having been conducted only 1-2 years after beltway completion, changes in travel behavior should be evident almost immediately.

Methodologies underutilized in these studies include multi-variate analysis, statistical hypothesis testing, and comparison of effects of the beltway with those of alternative transportation improvements.

Review of beltway impacts will follow the logic of the impact process by starting with effects on travel decisions, then effects on locational decisions of households, workers, and firms, and, finally, the consequences of such decisions, as reflected in development patterns, market effects, and environmental and socio-economic impacts.

Effects on Travel Decisions. Several of the studies examined this question; Most concluded that the beltways had affected or would affect travel decisions, encouraging more travel between suburban communities connected by the highway, but no analysis determined how many of these trips were new trips or, in fact, were formerly made to other destinations. The Maryland-Capital Beltway study estimated that the beltway incrased average trip length by 13 percent and travel time by 4 percent.[27]

In the Boston beltway corridor, the MIT study found that 47 percent of the employees at one industrial center adjacent to Route 128 had to shift their mode of travel from public transit or walking to driving, following the relocation of the plants.

Along the Capital Beltway in Washington, researchers found no relationship between beltway-oriented housing and beltway-oriented employment centers; people were not living close to work.

> According to commuter surveys, only a small percentage of Beltway-oriented apartment residents worked in nearby industries... Likewise the employees in Beltway industries showed no particular preference for Beltway-oriented housing. Many indicated they selected their present residence because of the Beltway, but for many this meant they could move even further into the suburbs and still commute to work via the Beltway and the interstate routes in a reasonable time.[28]

Effects on Employers' Location Decisions. Using survey information, investigators generally concluded that industrial location decisions were influenced by beltways in Boston, Raleigh, St. Louis, and Washington.

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27 Wilbur Smith and Associates, Maryland Capital Beltways Impact Study, (Washington SMSA and Maryland Counties), p. 160.

28 University of Virginia, op. cit., p. 119.

For example, nearly 80 percent of interviewed representatives from firms locating along the Washington beltway in Virginia stated that "knowledge of the route of the beltway or accessibility to it was a significant factor in site selection."[29] Authors of the Maryland Capital Beltway study concluded that "businessmen engaged in distribution of goods consider the beltway a very important locational factor."[30] The majority of Boston area firms selecting a Route 128 site considered other locations, primarily other suburban sites, according to the MIT study. Only 14.9 percent considered sites outside the metropolitan area, suggesting this is the largest number of jobs which could be said to have been "preserved" for the region by the development of Route 128.

Two limitations of these surveys should be recognized: (1) reasons stated for moving to a location may not always be the true reasons, and (2) location alternatives for these firms in the absence of the beltway were not addressed.

Finally, in St. Louis, researchers stated that "construction of the beltway is a positive influence on decreases in (industrial) land density."[31] Further, their regression model showed a positive relationship between employment density and labor force accessibility.

Effects on Workers' Location Decisions. Only one analysis surveyed workers in beltway industrial developments, finding that 29 percent of the workforce hired after the completion of the beltway said "the firm's location near the beltway was a major reason why they took the job."[32] Other studies reported that a beltway location attracted professional white collar workers but decreased the firm's ability to attract blue collar workers who were more likely to reside in the central cities. This was a particularly severe problem along the Washington beltway because of the scarcity of low cost housing in suburban communities and poor transit.

Effects on Households Location Decisions. The only analysis of this effect was conducted in the University of Virginia study of the Washington beltway. Forty-three percent of those interviewed at beltway-oriented workplaces indicated that the beltway influenced a residential move. Of the movers, approximately 10 percent formerly lived in Washington D.C. A substantial proportion of those influenced by the beltway moved significantly further into the suburbs, stating the beltway allowed them to live further from work and still have a reasonable length commute trip. The importance of the Washington beltway to residents of belt-oriented apartment complexes also was examined. Of those interviewed, 50 percent used the beltway for their work trip and 68 percent of that group stated that the beltway location was essential or very important for them.

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29 Ibid., p. 71.

30 Wilbur Smith and Associates, op. cit., p. 198.

31 deLeon/Enns, op. cit., p. 19.

32 University of Virginia, op. cit., p. 79.

Effects on Industrial, Commercial, and Office Development Decisions. Several studies determined that highways, including beltways, affected developers' siting decisions because of the accessibility and visibility of highway-served locations. Three studies relied on interviews and projections to determine the influence of the beltway on site selection, while two other investigators used regression models to identify the relationship between beltways and industrial development. With increasing dependence on truck rather than rail transportation for goods movement, manufacturing and distribution firms located on cheaper sites near suburban beltways without losing accessibility to markets.

Most studies did not analyze commercial and office development decisions because their uses usually follow residential development trends. Those that did identified effects similar to those on industrial development patterns. In Raleigh, Khasnabis and Babcock found a relationship between beltway access and office development, but did not include new CBD buildings in the model, concluding that many of these were government-related and constrained to locate downtown. According to Wilbur Smith and Associates, the Maryland Capital beltway would induce a shift of approximately 3,000 office jobs from Washington D.C. to the suburban counties by 1976.

None of these studies sought to isolate the beltway's influences from other factors affecting suburbanization of industrial activity and office employment.

Effects on Retail Development Decisions. Retail development locates in relation to population distribution. While there is no doubt that beltway interchanges are particularly attractive sites due to their visibility and accessibility, findings on beltway influence are somewhat mixed. The Urban Institute stated that:

> Beltways appear to have a strong impact on both the location of new shopping centers and their size... Even though the importance of the CBD as a major retail center has decreased in all of the cities (six-city sample), retail sales in the CBDs of cities with beltways has declined considerably more than in those without beltways.[33]

Contrary to this view, Wilbur Smith and Associates concluded that:

> The influence of the beltway on the allocation of future population is not expected to be large enough to alter significantly the geographic distribution of consumer demand. Significant positive impact will occur in certain locations next to the beltway; this will strengthen the tendency of developers to locate near the beltway where land is available.[34]

The affinity of shopping centers for beltway interchanges indicates a preference for such sites once demand is established, but does not entail an effect on the retail vitality of downtown.

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33 Urban Institute, op. cit., p. 17.

34 Wilbur Smith and Associates, op. cit., p. 84.

Effects on Housing Development Decisions. Beltway effects on housing development were documented in four studies. For medium- and high-density projects, most researchers identified the greatest effects on apartment location because visibility from the highway could help rentals. For single family housing adjacent to beltways, two detrimental effects were identified. First, noise and air pollution will influence a home buyer more than someone looking for an apartment, and second, increased land prices adjacent to the beltway reduce the feasibility of single family housing development.

The University of Virginia study determined that the Washington beltway caused a more compact form of residential single family development overall than would have occurred in its absence; "leap frog" residential development along outlying arterial highways would have been greater if the beltway had not opened up closer—in areas formerly lacking good highway access.

In Boston, investigators concluded that only a limited amount of residential development occurred because of the convenience offered by Route 128, while in Raleigh the beltway was viewed as a catalyst for suburban residential development. Only one study suggested that central city-to-suburb movement occurred as a result of a beltway; the others did not discuss how residential development patterns would have differed without a beltway.

Effects on Regional Employment Patterns. Based upon their location and development findings, most of the studies agreed that beltways affect the overall employment distribution within a metropolitan area. In Washington, for example, employment shifts attributable to the beltway would result in a loss of 10,000 jobs in Washington D.C. in 1976 or 1.5 percent of total projected employment. Maryland would gain 70 percent of these jobs and Virginia 30 percent.[35]

Effects on Downtown Retailing. Two studies found that beltways had major adverse effects on downtown retail trade.[36]

However, another analyst determined that neither shoppers' habits nor the extent of commercial development in the area was affected by a beltway three years after its opening.[37] Although 6 to 16 percent of shoppers at nearby regional centers used the beltway, many of them lived within the normal trade areas of the centers.

The FHWA researchers found that "beltway SMSAs show the most rapid rate of increase in retail employment outside central cities while at the same time the slowest rate of decline in retail employment in the central business districts."[38] This conclusion may result from different growth rates in the beltway and non-beltway metropolitan areas. However, it does suggest that evidence of beltways impacts on downtown retailing is not conclusive.

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35 Ibid., p. 115.

36 Khasnabis/Babcock, op. cit. p. 26; Urban Institute, op. cit. p. 20.

37 University of Virginia, op. cit., p. 118.

38 Federal Highway Administration, op. cit., p. 34.

Effects on Regional Housing Patterns. The FHWA analysis showed a positive relationship between beltways and the rate of suburbanization. However, this conclusion was distorted by differences in growth rates between the beltway and non-beltway metropolitan areas studied. The seven beltway metropolitan areas had a 24.5 percent growth rate between 1960 and 1970 in comparison with the 12.8 percent growth rate of the non-beltway sample—a difference not solely attributable to the beltways.

Effects on Property Values. Along the Capital Beltway, University of Virginia researchers found no relationship between the beltway and prices of single family homes. However, the price of land zoned for high intensity uses, particularly industry and multi-family housing, exhibited a positive relationship with access to the beltway.[39] In Boston, Bone and Wohl found that Route 128 had a positive effect on residential property prices.

In other studies, the influence of the beltway on residential property values could not be isolated and quantified.

Environmental Effects. Little attention was given by the beltway studies to this subject. One study found that noise levels near the beltway were high, but could be mitigated. None investigated the air quality or energy consumption impacts of beltways. The effects of beltways on conversion of open space and agricultural land to urban uses was not substantially discussed in any of the beltway studies. To the degree that beltways increased development on the fringe of metropolitan areas, they contributed to loss of open space. However, where they created a more compact urban form, the opposite effect occurred.

Fiscal Effects. There were two areas of concern: the effects of beltways on local governmental revenues, and the costs of beltway-induced infrastructure investments. Beltway studies gave some consideration to the first question, but none to the second. In Boston, new industry contributed a small per capita fiscal surplus to one community adjacent to the beltway. In Washington, Wilbur Smith and Associates stated that:

> Evidence is strong that the net result has and will be enlargement of the tax base and improvement in the position of taxing jurisdictions. The consultants believe that this general conclusion is not unique with the beltways, but rather that it is applicable to many modern urban highways.[40]

Whether this would result in a reduction of the tax base in the CBD or other areas from which industrial or commercial facilities move was not discussed.

None of the studies investigated the net fiscal impact of beltway-induced development, that is, the additional infrastructure and public service costs which can offset gains in tax revenues. Funding for access road improvements, sewer and water extensions, schools and police protection all represent costs which occur in those cases where beltways have induced growth.

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39 University of Virginia, op. cit., p. 49.

40 Wilbur Smith and Associates, op. cit., p. 201.

Effects on Employment Opportunity. Several of the beltway impact studies reported that beltways had a negative effect on the mobility and job accessibility of blue collar workers who for the most part were central city residents. The FHWA analysts cited a finding from another research project that many inner city workers do not follow a plant that relocates to the suburbs.[41] Since inner city workers are more likely than suburban workers to be minority group members, transfer of jobs from central cities to suburban communities may deprive lower income minority workers of certain job opportunities. Higher income workers who reside in outlying communities find their access to employment opportunities increased with the suburbanization of industry.

Effects on Housing Opportunity. Beltways increase the potential geographic area of residence for households seeking a suburban location within any given commute time. In addition, by creating sites appropriate for multi-family housing, beltways may contribute to the availability of such housing in suburban communities. There was little analysis of beltway effects on housing opportunity in the studies reviewed, but findings that central city blue collar workers did not stay with firms making suburban moves suggests that either few beltway communities provided housing opportunities for lower income residents or travel time and cost increases made long distance commuting unattractive and possibly unfeasible.

Effects on Land Use Policy. Several of the investigators reported a strong need for improved land use planning and public policy anticipation of development pressures resulting from beltways because few cities studied were prepared for growth which occurred around beltway interchanges. These effects were greater than those around radial interchanges since the beltways were built on open land, providing more opportunities for new development. Three studies noted that much of the new development did not conform to local planning policy and that zoning controls were relatively ineffectual in shaping growth rates and patterns.

Radial and Bypass Highway Case Studies

Hundreds of studies have been conducted on the economic and urban development impacts of both bypass and radial highways. None are exceptional, though several reports summarizing this body of work provide a useful critique of findings to date.[42,43] Most of the bypass studies examine how the highways affected the economy of towns or areas bypassed, concentrating on changes in retail sales and other indicators of business activity. Radial highway studies focused on land use and land value impacts.

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41 Burtt, Everett Jr., "Plant Location and the Core City Worker," U.S. Department of Housing and Urban Development, (Boston: Boston University, January 1967).

42 Horwood, Edgar, et al., Community Consequences of Highway Improvement, (Washington D.C. National Cooperative Highway Research Program (NCHRP) Report 18, Highway Research Board, 1965).

43 Winfrey, Robley, and Carl Zellner, Summary and Evaluation of Economic Consequences of Highway Improvement (Washington, D.C. NCHRP Report 122, 1971).

Objectives. Radial and bypass case studies had two primary objectives. Many were commissioned as public relations efforts and attempted to justify highways by showing the increased land values, a "non-user benefit," as the primary measure of a highway's economic effects. Another goal was to comply with legislative mandates, such as the 1956 Federal Highway Revenue Act which required "investigation of any direct and indirect benefits accruing to any class which derives benefits from Federal-aid highways."[44] In early studies, little attention was given to socio-economic or equity issues from a policy perspective. If a highway had positive effects on land values or use in a small area, the national effect was viewed as the aggregate of local effects. No impact study examined distributional issues or the equity issues.

Methodology. Both radial and bypass impact studies usually employed a before-after analysis technique with a control area to attempt to isolate highway impacts. In the radial studies, relative changes in property and land values were tabulated and compared to those in control areas. On the assumption that effects decreased with distance, data was disaggregated into bands by distance from the freeway or distance from the central business district (CBD). Sample size varied tremendously. Most studies used the difference in mean value increases as the indicator of effect, but statistical tests of significance rarely were presented to support or refute findings. Time periods of analysis ranged from 4 to 15 years, including pre-construction - construction - post-construction data in some cases, and only construction-post construction in others.

Several bypass studies focused on changes in retail trade, analyzing sales tax records for service stations, restaurants, and motels separately from all other retail activity, described as the "non-highway oriented" sector. For the most part, these studies used a four year study period, two years prior to completion and two after.

Findings and Limitations. By and large, radial freeways increased the value of adjoining property with the possible exception of single family homes. Industrial and commercial property usually was affected to a greater degree than was multi-family property; vacant land zoned for commercial or industrial use showed the greatest rate of increase. In some cases, values were diminished during the construction as a result of disruption and inconvenience. Measurements invariably were stated as a percentage increase or decrease in value or price relative to changes in the control area, an area supposedly not affected by the freeway. In fact, the evidence suggests that much of the increase in property prices adjacent to a freeway represented a transfer of value from areas relatively disadvantaged by the new facility, which often included the control area. This can happen for one or more reasons:

> Increasing the supply of land with superior accessibility may cause it to become so abundant relative to demand that the value of such land may diminish. The value of the latter land probably will be deflated by the added competition.

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44 Section 210(b)(3), Federal-Aid Highway Act of 1956.

> Drawing demand to locations advantaged by the improvement diverts it from other areas. Lowering demand in areas left with relatively inferior degrees of accessibility will tend to deflate values there.
>
> The new facility, because of its superior use benefits, causes modal and route, as well as locational, substitutions to occur. A reduction in the use of the modes and routes substituted for may deflate the value of land at locations geared to serve traffic moving by those former means.[45]

Studies of industrial or commercial developments influenced by freeway access enumerated the number of jobs or tax benefits associated with this growth; however, alternative locations for this development in the absence of the new highway rarely were discussed. In some cases, growth may have occurred without the facility; or the freeway may have brought new industry to a town; or it may have concentrated on new industrial and commercial facilities that previously were suburbanizing in scattered locations. Each of these outcomes would have different impacts on the central city, suburban communities, and metropolitan area as a whole. To determine accurately what was caused by the highway, it would be necessary to project what would have happened in its absence—an evaluation technique that rarely was used.

In addition, many of the variables used to measure economic effects were inadequate. Changes in assessed value data are a poor indicator of land value impacts, since assessments do not keep up with the market. The use of property sales data also has limitations, because sample sizes often are quite small and unrepresentative of the universe of parcels within impact areas.[46]

There have been two notable, recent reports on the effects of radial freeways on the location of office space and the location of industrial activity. A Federal Highway Administration-sponsored case study analysis of seven cities concluded that new suburban office building locations were influenced by radial and circumferential freeways because of the increased accessibility of office workers (middle and upper income) and improved access to vacant land.[47] There is little analysis of the synergistic effects of a radial and circumferential network or of the role of public policy and land use planning.

Another recent study conducted for the Federal Highway Administration found that central city radial freeways had a positive effect on manufacturing location decisions. This study, which presents an analysis of eight northeastern and southeastern cities, found that the radial freeways can have a major role in:

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45 Winfrey, Robley and Carl Zellner, op. cit., p. 317.

46 Horwood, Edgar, et al., op. cit., p. 20.

47 Ludwig, Armin, et al., Radial Freeways and the Growth of Office Space in Central Cities (Washington, D.C.: U.S. Department of Transportation, Federal Highway Administration, 1977).

- Revitalizing existing, declining central city industrial areas;
- Strengthening existing, stable industrial areas; and,
- Developing new industrial areas.[48]

This study of 264 firms concluded that in many cases, although a radial highway did not draw new firms to an area, it contributed to firms' decisions to remain in the central city and to upgrade their space. Firms most likely to stay in the central city:

- Were oriented to a central city unskilled or semi-skilled labor force;
- Served local markets or received supplies from local firms; or
- Depended on a relatively large amount of local shipping activity.[49]

Finally, the investigators determined that improvement of local street and utility infrastructure often was required to create an attractive central city industrial environment, and that urban renewal was needed as well to permit land assembly necessary to attract investors.

Highways and Regional Economic Development

Transportation improvements in a region do not have the economic effects today they once did. A new highway, whether radial or beltway, only has a marginal effect on overall mobility and travel decisions and, therefore, can be expected to have only marginal effects on regional growth and development. Studies of impacts of highways on degressed or static economies generally have shown smaller effects than were anticipated.[50] Particularly notable is a 1969 study on the effects of highways on urban manufacturing growth which concluded that the Interstate sytem had no effect on growth peformance with the exception of areas with dense populations and uneven terrain.[51]

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48 Hammer, Siler, George Associates, The Influence of Central City Radial Freeways on Manufacturing Location Decisions (Washington, D.C.: U.S. Department of Transportation, Federal Highway Administration, 1973), p. v.

49 Ibid.

50 Kuehn, John and J. West, "The Ozarks: Highways and Regional Development," Growth and Change: A Journal of Regional Development 2 (July 1971), pp. 23-28.

51 Wheat, L.F., "Effect of Modern Highways on Urban Manufacturing Growth," Highway Research Record 277 (1969).

A recent Urban Institute study found that the "presence of and/or potential for growth in market demand was the leading determinant of the regional location of new manufacturing plants."[52] Transportation facilities ranked fourth, following raw materials and labor force characteristics.

An unpublished study of regional economic development by the Brookings Institution indicates that the existance of a beltway has a small but significant positive effect on metropolitan economic growth.[53] Most analyses, however, continue to assume that highways do not affect the overall economic growth rate, but rather the distribution of employment within a metropolitan region.

Foreign Experience

There is little foreign experience with limited access beltways comparable to this country's. Because of significantly higher transit use and lower automobile ownership, highway and freeway networks are not as extensive as in the United States. This has been accomplished through tighter land use control, higher density cities, and continuing reliance on bus and rail for trips to the central business district, the destination of a greater proportion of trips than in this country. There are few radial freeways leading into city centers, and major inter-regional freeways tend to bypass cities just beyond the limits of urbanization.

In some cities, particularly major cities that are the focus of many radial links, partial or even full beltways have been built to connect the major routes; examples include Brussels, Cologne, Milan, Munich, and Utrecht. However, because of stronger land use control, these have remained beyond the limits of urbanization, have few ramps serving local destinations, and remain primarily inter-regional highways. These belts provide a vital function primarily because radial freeways do not continue through the center of town, as in American cities. Thus, there is no real alternative to the beltway for through traffic.

Many British and European smaller and mid-sized cities lacking highway bypasses have ringroads to encourage the diversion of through traffic around the city. In most cases, these roads are not limited access highways but wider city streets, often one way in smaller cities, Aix-en-Provence in France being a good example. Placement of such streets varies from just outside ancient city walls to corridors integrated with development of more modern neighborhoods. The objective of building these ring roads was to reduce traffic congestion in the old centers, designed and built well before the auto, and to remove heavy truck traffic, vibrations from which could threaten the structural integrity of older buildings.

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52 Reigeluth, George, and Harold Wolman, The Determinants and Implications of Communities' Changing Competitive Advantages: A Review of Literature, (Washington, D.C.: The Urban Institute, 1979), p. 26.

53 Kathy Bradbury, Brookings Institution, personal communication, October 1979.

Paris has built a circumferential freeway, "the peripherique," portions of which were built through urban areas. In London, the M25 Motorway is presently under construction. Completion of this single outer beltway around London was delayed for many years by debate on a previous plan which included three beltways and several additional radial freeways. The inner and intermediate beltways eventually were dropped because of tremendous public opposition reacting to extensive relocation, neighborhood effects, and the high cost.

In conclusion, while beltways have been built in some foreign (primarily European) cities, better integration of transportation planning and land use planning has resulted in few impacts comparable to the American experience.

SUMMARY OF LIMITATIONS OF PRIOR RESEARCH

Prior research and case studies on beltway's impacts on land use and urban development has four drawbacks, limiting its usefulness today. First, older studies of beltways' impacts, as well as other highway impact studies, focused on a narrow set of objective which rarely included policy issues now judged important: impacts on downtown and fiscal health of central cities, accessibility of employment and housing opportunities, energy consumption, and the environment. The alternatives to the beltway proposals were not examined in detail so the effects of one course of action could not be compared with another, or with a no-project alternative.

Second, the research to date does not offer any evidence about the long-term effects of beltways on urban areas. Nearly all prior studies looked at changes in land use, population growth, and economic activity that occurred one to three years after the beltway was completed; none of the comparative studies examined development trends in the mid-70s after the period of growth in the 1960s. A long-term perspective is important because highways are valuable infrastructure investments, to be maintained and improved from generation to generation. Short-term effects may be misleading, inaccurate measures of long-term influences. However, many beltways have been open to traffic for 20-25 years, so an assessment of their long-term effects can be made at this time.

Third, the analysis procedures used by prior researchers are not readily adaptable or transferrable to current planning efforts. In most cases, the investigation relied on empirical measures and projections of trends to predict future conditions. Sensitivity analysis rarely was undertaken, nor were the effects of alternatives on development patterns determined.

Finally, the prior studies of beltways do not provide much help for those trying to design an action program that will include measures to enhance the benefits and, when necessary eliminate adverse effects or compensate those affected by other actions. Today, a transportation planner's responsibility to the community at large is far greater than it was in the 1940s, 50s, or even 60s, when his main charge was to design a system to meet anticipated travel needs. Concern for the socioeconomic, fiscal, and environmental effects of highway projects, including their impacts on energy consumption is now a planning requirement. New tools are needed; empirical research can provide a good starting point, but it cannot offer all the answers.

3. COMPARATIVE STATISTICAL ANALYSIS

OBJECTIVES

There were two primary objectives for conducting a comparative statistical analysis of beltway influence on development patterns. The first was to update and expand further the previous evaluations of the beltways' effects on metropolitan and central city population and economic development trends, using recently released demographic and economic data for the mid to late 1970s. The second objective was to allow a quantitative analysis of the similarities and differences between cities in relation to beltway existence, location, and age. An understanding of these basic differences was essential for selecting a good sub-sample for the detailed case studies, and for focusing the subsequent analysis of the particular beltway impacts suggested by the statistical work.

METHODOLOGY

The analysis methodology was designed to allow a multivariate analysis of beltway influence, both as an independent variable and in conjunction with other variables, on metropolitan and central city employment, trade, population, travel, and energy consumption patterns. A large data base was used to expand upon previous analytical studies, alleviating the shortcomings associated with small samples, single variate analysis, and lack of extensive post-construction data. The following sections trace the methodology used to: establish testable hypotheses, select the maximum sample size possible, and develop the data base. Limitations of the analysis also are indicated.

Issues and Hypothesis Formulation

Federal, metropolitan, and local policy issues were identified early in the study, presenting the range of concerns associated with a beltway's potential impacts on urban development. In order to conduct statistical tests, the policy issues were restated as testable hypotheses to be accepted or rejected based on the evidence.[1] Hypotheses that were tested are presented in Table 3.1.

Many of the policy issues could not be statistically tested because of a lack of consistent quantitative information. The list in Table 3.1 includes those issues for which data were available.

Sample Selection

Initially, a large group of cities was chosen to represent as nearly as possible the universe of American metropolitan areas with substantially complete beltways. A large sample size allowed the use of multivariate analysis techniques, and it avoided the bias in small samples caused by unique characteristics of one or two areas.

All beltway cities with a complete 360 degree arc were included as well as those beltway cities where the arc, although incomplete, was as substantially built out as

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[1] Using standard practice, the hypotheses are presented in the form of null hypotheses.

TABLE 3.1 RESEARCH HYPOTHESES

Beltway Growth Inducing Effects

Population

1. Beltways do not have any consistent, significant effect on the overall rate of metropolitan population growth.

Manufacturing Activity

2. Beltways do not stimulate the rate of growth of metropolitan manufacturing activity (basic employment, value added, and capital investment).

Employment

3. There is no difference in the overall rate of metropolitan non-basic employment growth that can be attributed to a beltway.

Beltway Distributional Effects

Population

4. Beltways do not have any effect on central city population growth.

Manufacturing Activity

5. Beltways have no effect on the distribution of manufacturing activity (basic employment, value added, and capital investment) within metropolitan areas.

Employment

6. There is no difference in central city employment growth that can be attributed to beltway existance or characteristics.

Retail Sales

7. Beltways and their characteristics have no discernable effect on changes in central city or central business district (CBD) retail sales.

Transportation and Commuting

8. Beltways have no significant effect on vehicle miles traveled (VMT) and are unlikely to have effects on energy consumption and air quality.

9. Beltways have no effect on suburban commuting patterns.

Housing

10. The proportion of new SMSA housing built in the central city is not affected by development of a beltway.

Equity and Equal Opportunity

11. Beltways do not affect residential suburbanization rates and the suburbanization of the minority population; nor do they affect suburbanization of employment opportunities.

possible. Coastal cities with a 200° possible beltway arc, for example, were classified as a beltway city if a partial circumferential route had been built. Non-beltway metropolitan areas were selected to complement the beltway candidates in size and geographical distribution. Table 3.2 shows the initial candidates for the beltway and non-beltway samples.

Beltway Metropolitan Areas. Screening criteria identified an initial set of candidates for the comparative statistical analysis. Most important was the decision to limit the study to standard metropolitan statistical areas (SMSAs) with limited access beltways. Few, if any, non-metropolitan areas have limited access circumferential highways, and equivalent census data are not available for these areas. Because of the great difference in likely impacts, no unlimited access circumferential boulevards were included; the sample and the entire study were limited to the analysis of effects of limited access freeway or expressway beltways.

TABLE 3.2. INITIAL CANDIDATES FOR COMPARATIVE STATISTICAL ANALYSIS

Large Metropolitan Areas		Other Metropolitan Areas	
Beltway	Non-beltway	Beltway	Non-beltway
Atlanta, GA	Hartford, CN*	Columbia, SC*	Akron, OH
Baltimore, MD	Kansas City, KA	Davenport, IO*	Albany, NY*
Boston, MA	New Orleans, LA	Lexington, KY	Albuquerque, NM
Buffalo, NY	Phoenix, AR	Louisville, KY	Amarillo, TX*
Cleveland, OH	Pittsburg, PA	Lubbock, TX	Baton Rouge, LA*
Columbus, OH	Portland, OR	Memphis, TN	Birmingham, AL
Dallas-Ft. Worth, TX	San Diego, CA	Montgomery, AL*	Canton, OH*
Denver, CO	Seattle, WA	Nashville, TN	Charlotte, NC
Houston, TX	Tampa-St. Peters-	Oklahoma City, OK	Chattanooga, TN
Indianapolis, IN	burg, FL	Omaha, NE	Dayton, OH
Milwaukee, WI		Raleigh, NC	Fresno, CA
Minneapolis-St. Paul, MN		Rochester, NY	Grand Rapids, MI
Philadelphia, PA*		San Antonio, TX	Jacksonville, FL
St. Louis, MO		Toledo, OH	Knoxville, TN
Washington, DC		Wichita, KA	Little Rock, AK
			Madison, WI
			New Haven, CN*
			Richmond, VA
			Sacramento, CA
			Salt Lake City, UT
			Spokane, WA
			Syracuse, NY
			Tucson, AR
			Tulsa, OK
			Youngstown, OH*

*Excluded from final sample.

1970 population data were used to screen out SMSAs over 3 million and central cities under 100,000.[2] This focused the analysis on the dynamics in moderately large to small size areas and eliminated the analytical problems associated with multiple central city SMSAs lacking a clearly-defined central business district—the Quad cities in Iowa and Illinois, for example. The only SMSA with a partial beltway excluded by the 3 million population maximum was Philadelphia. Metropolitan areas were classified into two categories, with population size of one million as the dividing line.

Non-Beltway Metropolitan Areas. The same initial screening criteria were used for the non-beltway sample. SMSAs on the suburban fringe of nearby, large metropolitan areas, such as New York, Los Angeles, and San Francisco-Oakland were excluded. This eliminated suburban SMSAs which are not freestanding but a part of a larger standard consolidated statistical area. Candidates also were eliminated from the list if the central city contained a low proportion of SMSA population (Albany, New York, Hartford and New Haven, Connecticut). The results of this screening are summarized in Table 3.2. Included in the non-beltway sample are several cities where partial or full beltways have been proposed, including Dayton, Ohio; Richmond, Virginia; Salt Lake City, Utah; and Tulsa, Oklahoma.[3] The final sample for the comparative statistical analysis consisted of 27 areas with beltways and 27 without.

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2 The term central city, used extensively in this analysis, refers to the political jurisdiction of the primary city of the SMSA. Central business district (CBD) is used when referring to the core of the city.

3 On November 29, 1979, The Secretary of Transportation rejected the proposed Dayton partial beltway because it would conflict with President Carter's urban policy.

Data Base and Analytical Techniques

Data were collected in seven basic categories including: general economic and demographic information, employment and investment figures, retail trade statistics, commuting information, highway and beltway descriptions, socioeconomic indexes, and residental moving patterns. These categories permitted an analysis of beltway influences on population, employment, trade, residential movement, work location, and vehicle miles traveled, corresponding to the testable hypotheses developed from the beltway policy issues. The large data base also allowed the development of multivariate models of relationships between beltways and other factors. Data were collected for the 1960-1977 time period whenever available, and for both SMSAs and central cities. In addition, retail sales data were gathered for central business districts (CBD) for 1967 through 1977. The data base was similar to those used in current modeling efforts of the Federal Highway Administration and the Brookings Institution.[4]

Table 3.3 presents the data assembled for the comparative statistical analysis. Much of the information came from the Bureau of the Census as published in the County and City Data Books; other data were obtained directly from the 1970 Census of Population and Housing, the 1977 Censuses of Retail Trade and Manufacturing, and a variety of other government documents. Full documentation of sources is contained in the bibliography (Appendix G). Data were collected for all 54 metropolitan areas with several exceptions; these included the Annual Housing Surveys, available for only two-thirds of the sample, and the 1977 Census of Manufacturing, unavailable for central cities at the time of the analysis.

The data base included indicators of several beltway characteristics. Simplest was a dummy variable indicating the existence of a beltway. Other measurements related to beltways were: length in miles, number of interchanges, interchange density per mile, percentage of potential arc built, age, and location, both in terms of distance from the CBD and in terms of political jurisdiction (central city or suburb) in which the beltway is located. This latter variable, labeled "beltway location," is a continuous variable which relates the beltway location to existing political boundaries that characterize the central city-SMSA distinction in many of the data sources.

Other transportation measures included: arterial mileage per capita, an index of major route mileage; daily vehicle mileage per capita; vehicle miles per capacity mile, a measure of highway utilization that incorporates lanes as well as mileage, and therefore provides a congestion index; and a transit capacity index, measured in vehicles per 1,000 persons (corrected for greater passenger capacity of rail cars). Beltway and other transportation indices were collected for the most recent time period and generally represented 1975-78 data.

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4 Works in progress, respectively titled: The Impact of Circumferential Highways on the Central Cities and Suburbs; and Urban Decline and the Future of American Cities.

TABLE 3.3. DATA BASE FOR COMPARATIVE STATISTICAL ANALYSIS

Variables	Geographic Coverage SMSA	Geographic Coverage CC	Years
General Economic and Demographic Data			
Land Area*	x	x	'60, '70, '77
Population*	x	x	'50, '60, '70, '77
Pop. Percent Black*	x	x	'60, '70
Net Migration	x		'60-'70, '70-'75
Total Employment*	x	x	'60, '70
Percent Manufacturing Employment	x	x	'70
Percent Trade Employment (wholesale & retail)	x	x	'70
Percent Government Employment	x	x	'70
Per Capita Income	x	x	'74
Annual Increase Per Capita Income	x	x	'69-'74
Poverty Level Families	x	x	'69
Housing Units	x	x	'70
Change in Housing Units	x	x	'60-'70, '70-'76
Occupied Housing Units (Households)	x	x	'60, '70
Owner Occupied Housing Units	x	x	'70
Percent Single Family New Units	x	x	
Per Capita Property Tax	x	x	'71-'72
Governmental Expenditure (Highways)	x	x	'71-'72
Employment and Investment			
Manufacturing Employment*	x	x	'63, '67, '72 ('77 SMSA only)
Manufacturing Capital Expenditure*	x	x	'63, '67, '72 ('77 SMSA only)
Percent Change Value Added Manufacturing*	x	x	'63-'67, '67-'72 ('72-'77 SMSA only)
Selected Services Employment*	x	x	'63, '67, '72
Wholesale Employment*	x	x	'63, '67, '72
Retail Trade			
Retail Trade Establishments*	x	x	'63, '67, '72, '77
Auto Dealer Establishments*	x	x	'63, '67, '72, '77
General Merchandise Establishments*	x	x	'63, '67, '72, '77
Eating and Drinking Establishments*	x	x	'63, '67, '72, '77
Total Retail Sales*	x	x	'58, '63, '67, '72, '77
Auto Dealer Sales*	x	x	'63, '67, '72, '77
General Merchandise Sales*	x	x	'63, '67, '72, '77
Eating and Drinking Sales**	x	x	'63, '67, '72, '77
Total Retail Employment*	x	x	'63, '67, '72, '77
Selected Services Establishments**	x	x	'63, '67, '72

*Indicates that a transformation variable was created expressing the percentage change in this variable between time periods.

**Not available for all metropolitan areas.

Source: Blayney-Dyett

TABLE 3.3. DATA BASE FOR COMPARATIVE STATISTICAL ANALYSIS CONT.

Variables	Geographic Coverage SMSA	Geographic Coverage CC	Years
Commuting Data			
Percent Suburban Resident Working in CBD	x		'70
Percent Suburban Resident Working CC not in CBD	x		'70
Percent Suburban Resident Working Outside SMSA	x		'70
Median Job Distance—Owners**	x	x	'74, '75, or '76
Median Job Distance—Renters**	x	x	'74, '75, or '76
Median Work Trip Travel Time—Owners**	x	x	'74, '75, or '76
Median Work Trip Travel Time—Renters**	x	x	'74, '75, or '76
Moving Data (Suburban Movers)			
Owners Moving From Central City**	x		'74, '75, or '76
Owners Moving From Outside SMSA**	x		'74, '75 or '76
Renters Moving From Central City**	x		'74, '75 or '76
Renters Moving From Outside SMSA**	x		'74, '75 or '76
Black Owners Moving From Central City**	x		'74, '75 or '76
Black Owners Moving From Outside SMSA**	x		'74, '75 or '76
Black Renters Moving From Central City**	x		'74, '75, or '76
Black Renters Moving From Outside SMSA**	x		'74, '75, or '76
Percent Black Owners Moving**	x		'74, '75 or '76
Percent Black Renters Moving**	x		'74, '75 or '76

Variables	Geographic Coverage SMSA	Geographic Coverage CC	Years
Highway and Beltway Data and Descriptions			
Freeway Mileage	x		'75
Freeway DVMT as Percent of Total VMT	x		'75
Principal Arterial Miles/1,000 Persons	x		'75
Daily VMT/1,000 persons	x		'75
Existence of Beltway	x		'77
Beltway Location, CC or Suburban	x		'77
Beltway Mileage	x		'77
Beltway Distance from CBD	x		'77
Beltway Interchanges	x		'77
Age of Beltway	x		'77
Proportion of Beltway in Interstate System	x		'77
Proportion of Full Circle Described by Beltway Arc	x		'77
Transit Capacity Measure	x		'76
Vehicle Miles/Capacity Miles	x		'72
Indexes and Other Data			
HUD UDAG Points**		x	'77
Brookings Needs Index**	x	x	
City Age (Decades Since 50% of '70 Population)		x	
Degree Days (cold weather)	x		
Year of Annual Housing Survey**			'74, '75, '76
Vacant Land Availability**		x	'70
Community Development Block Grant Entitlement (1975-77)		x	'77

**Not all areas covered.

Two types of statistical analysis techniques were used to test for beltway influence: the first was analysis of variance using either two or four sub-groups of the data; the second was multiple regression, using beltway characteristics as well as other independent variables in analyzing joint relationships and independent beltway influence on dependent variables. For dependent variables reflecting time series data, percentage change over a given time period was used. While this emphasizes impacts in smaller areas, use of absolute change data would bias results toward larger areas and not focus on changes in the distribution of new development and economic activity.

For comparisons between metropolitan areas, continuous data were transformed to discrete data, and beltway location or age were classified into several groups rather than maintained as individual distinct measures for each SMSA. For example, beltway location was classified into three groups: a beltway located in the central city—one in which 70-100 percent of the beltway mileage was in the political jurisdiction of the central city; a suburban beltway—one in which 70 percent or more was located in jurisdiction other than the central city; and a mixed jurisdiction beltway—encompassing the remaining group, those in which between 30 and 70 percent of the mileage was located in either central city or suburban jurisdictions.

The beltway location variable was selected as a useful beltway measure because it represents a policy-related attribute of a beltway. This variable was selected over beltway existence or arc as the primary measure of a beltway because it shows the transfer and distributional effects of a beltway. By setting a totally central city beltway equal to no beltway (a zero score), a beltway location in the city would have a similar effect on the central city as no beltway in terms of diversion of business and population activity to the suburbs.

To avoid missing potential beltway influences, two other beltway variables were used in conjunction with jurisdictional location; these also maintained a distinction between no beltway and a central city beltway. Beltway length (mileage) and interchange density per mile were selected as other beltway measures, in part because length was particularly important in several of the models, and also because these two factors were less correlated with beltway location than other beltway measures such as age or arc. Table 3.4 presents the correlation coefficients of all beltway variables.

To test whether beltway location was a unique characteristic unduly affecting the outcome of the regression models, separate models using the distance of the beltway from the core and other beltway variables were run for some dependent variables.

Finally, the beltway measures were used only if the beltway had been completed and opened for traffic during the time period analyzed. Using this technique, the number of beltways was 27 for analysis of effects since 1975, 25 for analysis fo 1967-72 changes, and 14 for analysis of 1963-67 changes. Because of the later completion of several beltways and the importance of beltway age on land use effects, separate five year time periods were used for analysis rather than one run of 10-year changes.

TABLE 3.4. CORRELATION MATRIX: BELTWAY INDICATORS

	BELT	BWLOCP	BMI	BDEN	BINT	BLARC	BAGE
BELT							
BWLOCP	.7043						
BMI	.7732	.6221					
BDEN	.8684	.5706	.5546				
BINT	.7923	.6004	.9175	.7507			
BLARC	.9608	.6715	.8411	.8400	.8570		
BAGE	.8678	.7269	.6417	.6884	.6372	.8067	
BDIS	.8846	.7902	.8340	.6787	.7805	.8591	.7897

BELT = Beltway Existence
BWLOCP = Beltway Location (Percent Suburban Jurisdiction
BMI = Beltway Mileage
BDEN = Interchanges Per Mile of Beltway
BINT = Number of Beltway Interchanges
BLARC = Proportion of Potential Beltway Arc
BAGE = Beltway Age
BDIS = Beltway Distance from CBD

Several variables that were incorporated in other studies have not been used in this analysis. Economic cycles and inflation that affect certain variables, such as manufacturing capital investment or retail sales, were not taken into consideration. Evidence suggests that economic cycles and inflation as it affects retail sales have been relatively consistent throughout the country over a given time period. Further, the impact of these factors was assumed to be unrelated to the influences of the beltway variables used in this analysis. The main purpose of the analysis was to determine whether and to what degree beltways have affected urban development patterns relative to other metropolitan area influences. Using the findings and unindexed variables for predicting future impacts based on the derived coefficients would be carrying the results beyond their potential validity.

Limitations

Limitations of this analysis primarily stem from empirical rather than conceptual problems. While a statistical relationship does not automatically show causality, one that can be cited with a high degree of confidence does suggest that effects are highly probable.

Like many statistical analyses, data limitations are important and cannot be overlooked. The use of SMSA and central city data masks effects on central business districts (CBD) which may be of great interest. Differences in area and type of development within the central city can overshadow beltway effects on the CBD.

The Major Retail Center (MRC) data from the 1977 Census of Retail Trade were not released in time for inclusion in the comparative statistical analysis.[5] Sales trends in MRCs were tracked for the eight metropolitan areas subjected to greater analysis in the detailed case studies. Finally, lack of data on residential moving patterns for many of the case study areas limited analysis of beltway effects on household location decisions.

The data represent virtually all metropolitan areas with beltways; hence, sample size should not cause a substantial potential for error. The absence of a group of non-beltway metropolitan areas that match all other characteristics of the beltway group results from a lack of such areas rather than a failure to include them within the sample. Differences in characteristics between beltway and nonbeltway areas are described in the following section.

Because the Census of Population and Housing is conducted in every decade and the Economic Censuses generally at five year intervals (1967, 1972, 1977), economic and demographic data do not match up. Thus, compromises were required to develop logical equations for the regression analysis. While use of data from non-matching years does add an element of approximation, this should not affect the validity of the finding.

Multicollinearity between beltway influences and those of other variables such as metropolitan population, city age, and central city manufacturing employment growth makes it difficult to separate out any beltway influence in several models. Where high correlations (.7 or more) between independent variables were evident, non-significant variables are reported if there seemed a high likelihood of multicollinearity having affected the significance of individual variables.

Following standard practice, a 95 percent confidence level was set as the criterion for hypothesis testing. This is a rigorous level which limits the likelihood of accepting a hypothesis of a beltway impact when there was none. However, this does increase the probability that there may have been some small beltway effects which could not be identified statistically (a Type II error).

SIMILARITIES AND DIFFERENCES

Important similarities and differences exist between metropolitan areas with and without beltways as well as among areas with beltways. Understanding these is the first step in learning how beltways affect metropolitan development patterns and the economies of central cities and of regions.

Beltway vs. Non-beltway Areas

There are statistically significant differences between beltway and non-beltway metropolitan areas in terms of population, density of development, economic health, and recent migration trends. Table 3.5 illustrates a few of these and indicates which differences are statistically significant at the 95 percent confidence level.

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5 U.S. Department of Commerce, Bureau of the Census, 1977 Census of Retail Trade: Major Retail Centers in SMSAs (Series RC77-C) (Washington, D.C., 1980).

TABLE 3.5 COMPARISON OF BELTWAY AND NON-BELTWAY STUDY AREAS

	Beltway		Non-Beltway	
	Mean	Standard Deviation	Mean	Standard Deviation
Metropolitan Area Population, 1977*	1,407,000	916,000	833,000	479,000
Percent Change, 1960-77	42.5	40.8	40.3	25.5
Central City Population, 1976*	533,000	294,000	328,000	175,000
Percent Change, 1960-76*	16.0	52.8	19.8	39.1
Metropolitan Area Population Density, 1977 (Persons Per Square Mile)*	511	326	311	195
Degree Days (Cold Weather Index)*	4,783	1753	3,971	1,993
UDAG Program Index[a]	4.4	2.0	3.5	2.2
Brookings Hardship Index[b]	173	125	137	93
Freeway Mileage in the SMSA, 1975				
Vehicle Miles Traveled per Capita in the SMSA, 1975	14.95	3.6	14.68	3.2
Transit Availability Index[c] in the SMSA, 1976	.35	.17	.29	.13

* Difference significant at the .05 level.

a. A score of seven indicates maximum distress, zero indicates minimum; a score of four is required to qualify for the program. Points are based on comparative city averages of unemployment, poverty level households, lack of income and population growth, and the proportion of older housing in the city.

b. A score of 100 indicates equal distress in the central city and rest of the SMSA. Scores above 100 indicate greater distress in the central city, score below greater distress elsewhere in the SMSA. The index is also based on demographic and socioeconomic statistics.

c. Transit vehicles per 1,000 persons.

Population among the beltway metropolitan areas in 1970 ranged from 2.9 million for Boston and Washington, D.C. to 189,000 in Lubbock, Texas. For the non-beltway group, the largest was Pittsburgh with 2.4 million, the smallest, Spokane with 287,000. However, the average SMSA and central city population was substantially greater for the beltway group. The primary difference was that nine of 10 metropolitan areas containing 1.5 million population or more had beltways.

Although the overall population growth rate between 1960 and 1977 was similar, 42.5 percent vs. 40.5 percent, in-migration since 1970 averaged only .5 percent for beltway SMSAs in comparison with 4 percent for non-beltway SMSAs. In non-beltway metropolitan areas, 1960-76 population growth in central cities was greater, 13 percent versus 3 percent in beltway areas. However, in both groups the average central city population represents about 35-40 percent of the metropolitan area population, 532,000 for beltway areas and 328,000 for non-beltway areas, while the standard deviations were 294,000 and 175,000 respectively. The extremes were Houston with 1.45 million and Raleigh with 137,000. Five of six central cities with more than 700,000 residents are in areas with beltways.

In 1977, the average size of beltway metropolitan areas was smaller than that of non-beltway areas, 3,000 square miles versus 3,493 square miles. The smallest area was Lubbock, Texas, with 893 square miles; the largest, Tucson with 9,240 square miles. When combined with the smaller population, a significant difference in population density emerges: 532 persons per square mile in beltway SMSAs and 310 persons per square mile in non-beltway areas.

Nationally, the trend has been to build beltways in progressively smaller metropolitan areas, as Table 3.6 shows.

TABLE 3.6. SMSA POPULATION BY AGE OF BELTWAY

	Mean	Standard Deviation	Number of Observations
No Beltway	833,000	483,000	27
Beltway Age			
1-4 years	1,046,000	387,000	2
5-9 years	1,218,000	868,000	11
10-14 years	1,484,000	624,000	9
15 or more years	1,824,000	1,570,000	5

Other statistics suggest that a beltway metropolitan area on average has colder weather, greater central city economic hardship as reflected in scores on the HUD and Brookings indexes of economic distress, and a better transit system than an area without a beltway. This is due to the preponderance of older eastern and midwestern cities among the beltway group and "sunbelt" cities among the non-beltway sample.

Total 1975 freeway mileage averaged 129 miles in beltway SMSAs in comparison with 78 miles in non-beltway areas. However, on a per capita basis, the latter group is slightly better endowed with freeways despite the lack of beltways. The proportion of total vehicle miles traveled (VMT) on freeways was slightly higher in the beltway areas, 32 percent in comparison with 28 percent for non-beltway areas. Daily VMT per capita was very similar, 14.95 miles in beltway metropolitan areas and 14.68 for non-beltway SMSAs. Standard deviations in VMT were 3.6 miles and 3.2 miles respectively.

TABLE 3.7. COMPARISON OF STUDY AREA CHARACTERISTICS BY BELTWAY LOCATION[a]
Mean and (Standard Deviation)

	No Beltway	Central City Beltway	Mixed Jurisdiction	Suburban Beltway	Average all Beltways	Overall Sample Average
City Age Index	4.3 (2.4)	2.4 (.9)	4.8 (2.3)	7.3 (1.9)	5.1 (2.0)	4.6 (2.6)
Central City Land Area 1977 (square miles)[b]	134 (150)	330 (202)	191 (196)	79 (26)	188 (170)	161 (167)
SMSA Population, 1977 (000's)	833 (479)	901 (730)	1,193 (679)	1,975 (930)	1,407 (916)	1,120 (780)
Central City Population 1976 (000's)	328 (775)	560 (446)	499 (302)	538 (141)	533 (294)	430 (261)
Central City Population, Percent Black	16 (13)	18 (10)	17 (6)	31 (21)	23 (18)	20 (15)
Central City Percent Vacant Land[c]	24 (14)	36 (8)	14 (7)	8 (7)	18 (12)	21 (14)
SMSA Transit Index (Vehicles per 1,000 persons)	.29 (.13)	.23 (.10)	.32 (.5)	.47 (.20)	.35 (.17)	.32 (.15)
Freeway Miles SMSA, 1975	78 (67)	84 (68)	126 (110)	163 (56)	129 (100)	104 (78)
Urban Development Action Grant (UDAG) Index[c]	3.5 (2.2)	2.0 (1.1)	4.1 (2.0)	5.6 (1.3)	4.4 (1.8)	4.1 (2.1)
Brookings Needs Index	138 (93)	75 (29)	132 (83)	286 (112)	172 (100)	155 (110)

a. All differences are statistically significant at the .05 level.

b. Lexington excluded because of city-county consolidation.

c. Data not available for full sample of 54 cities.

Beltway Location

Areas with beltways in the central city are significantly different from those where the beltway is located primarily outside the central city in terms of central city land area, annexation patterns, amount of vacant developable land; transit availability; and the UDAG and Brookings indexes of relative socioeconomic hardship (see Table 3.7).

Table 3.8 shows the principal characteristics for each beltway included in the analysis, stratified by jurisdictional location. There is a relationship between the beltway's distance from the central business district and jurisdictional location. Central city beltways were located an average of 6.3 miles from downtown, beltways in the suburbs and the central city, called "mixed jurisdiction," average 6.6 miles from the CBD, and suburban beltways, 9.9 miles. The beltway closest to downtown is in Raleigh (4 miles). In Cincinnati and St. Louis, the beltways are 12 miles out; in Cleveland, it is 15 miles from downtown. Given the larger population served by suburban beltways, the greater distance from the CBD makes intuitive sense.

TABLE 3.8. BELTWAY CHARACTERISTICS BY LOCATION

Central City	Location (Percent in Suburban Areas	Distance from Central Business District (Miles)	Percent of Potential Arc Built	Length (Miles)	Interchanges per Mile
Houston	5	5	100	44	1.25
Indianapolis	5	8	100	58	.50
Lexington	0	5	80	23	.35
Lubbock	0	6	100	26	.88
Memphis	0	8	59	15	.87
Oklahoma City	0	5	100	20	1.70
Raleigh	0	4	55	14	.64
San Antonio	10	9	100	64	.64
Average		6.3 (1.83)	85.6 (21.6)	33 (19.7)	0.85 (0.44)
Mixed Jurisdiction					
Columbus	55	10	100	56	.43
Dallas-Ft. Worth	40	10	95	110	.80
Denver	60	9	80	39	.95
Louisville	40	5	65	23	1.22
Nashville	70	5	50	16	.81
Omaha[a]	50	5	100	22	1.27
Toledo	50	6	75	36	.72
Rochester	70	3	80	21	1.38
Average[a]		6.6 (2.7)	80.6 (17.6)	40.4 (30)	.95 (.32)
Suburban					
Atlanta	80	9	100	64	.71
Baltimore	95	7	100	51	.90
Boston	100	11	90	42	.93
Buffalo	100	8	90	19	.68
Cincinnati	100	12	95	77	.49
Cleveland	100	16	60	26	.73
Milwaukee	85	7	70	17	1.41
Minneapolis-St. Paul	100	11	100	54	1.00
St. Louis	99	12	65	54	.63
Washington, D.C.	100	9	100	66	.68
Wichita	100	7	75	30	.33
Average[a]		9.9 (2.8)	85.9 (15.4)	45.5 (20.2)	.77 (.29)

a Standard deviation shown in parentheses

b. The city has annexed the beltway right of way, but large unincorporated areas remain inside the beltway. For this reason, Omaha was classified initially as a "mixed jurisdiction" beltway. The mileage includes I-80, a radial highway.

TABLE 3.9. METROPOLITAN POPULATION GROWTH BY BELTWAY PRESENCE, 1960-70

Beltway	Fast Growth (20 Percent or More)	Slow Growth (Less Than 20 Percent)	
Central City	Houston	Indianapolis	
	Lexington	Lubbock	
	Oklahoma City	Memphis	
	Raleigh		
	San Antonio		
Mixed Jurisdiction	Columbus	Louisville	
	Dallas-Ft. Worth	Nashville	
	Denver	Omaha	
	Rochester	Toledo	
Suburban	Atlanta	Baltimore	Cleveland
	Minneapolis/St. Paul	Boston	Milwaukee
	Washington, D.C.	Buffalo	St. Louis
		Cincinnati	Wichita
Non-Beltway	Albuquerque	Akron	Pittsburgh
	Charlotte	Birmingham	Richmond
	Madison	Chattanooga	Spokane
	Phoenix	Dayton	Syracuse
	Portland	Fresno	Tulsa
	Sacramento	Grand Rapids	
	Salt Lake City	Jacksonville	
	San Diego	Kansas City	
	Seattle	Knoxville	
	Tampa-St. Petersburg	Little Rock	
	Tucson	New Orleans	
		Pittsburgh	

The city age index, measured as the number of decades since the central city attained one-half of its 1970 population, gives an indication of both age and recent growth. The average age index of central cities surrounded by suburban beltways was almost three times greater than those with beltways within the central city. Beltway cities together are slightly older than non-beltway cities, but this difference is small.

The greatest difference is in central city land area and percent change in land area over a seven-year period. Central cities containing beltways average more than four times the land area of cities with suburban beltways, although with a large standard deviation. Oklahoma City, Dallas-Ft. Worth, Houston, Lexington, and Nashville were all over 400 square miles, while Boston, Buffalo, Raleigh, and Rochester were each under 50 square miles in 1977.

Another distinguishing characteristic is that 1976 central city population was fairly uniform for the three groups; thus the average central city containing a beltway represented over twice the proportion of SMSA population than central cities with a suburban beltway.

The amount of vacant land in the central city differs among groups, with cities surrounded by suburban beltways having little opportunity for new development with the exception of redevelopment. Central cities containing beltways or those with no beltway in the metropolitan area had four times more developable land in 1971, the year the vacant land index was compiled. The percentage of vacant developable land in the central cities ranged from two percent in Cleveland and four percent in Minneapolis-St. Paul to 42 percent in Lubbock and 45 percent in Houston.

Transit capacity and service also differ greatly, with the older, smaller central cities in SMSAs having about double the capacity per capita as do the younger, physically larger central cities. Freeway mileage is in approximate ratio to SMSA population with central city and mixed jurisdiction beltway SMSAs having slightly more miles per capita.

Finally, clear distinctions emerge when comparing the beltway and non-beltway areas in terms of broad socioeconomic indexes. For the central cities with a population greater than 250,000 that are potentially eligible for the HUD Urban Development Action Grant (UDAG) program, the index varies significantly depending on whether the beltway is located primarily in the central city (average 2.2 score) or primarily in the surrounding suburban communities (average of 5.6 score). Houston and Omaha both had one point, while Cincinnati, Cleveland, and St. Louis were in the maximum distress category, scoring seven. The scores on the Brookings Hardship Index are similar: 138 for central cities in non-beltway areas, 172 for central cities in beltway areas; and a further breakdown of 72 for central cities containing a beltway within the city and 286 for central cities that have a beltway in the surrounding suburban communities. Thus, the average central city containing a beltway was better off than the remainder of its metropolitan areas in terms of unemployment, poverty, growth in income, etc. Nashville, Houston, Lexington, and Raleigh had scores of 50 or less, suggesting greater poverty and distress in suburban or rural areas of the SMSA, while Boston, Buffalo, Cleveland, and St. Louis had scores over 300. While the standard deviations for many of these indexes are large, differences are still significant.

Metropolitan population growth rates are shown in Table 3.9. Between 1960 and 1970 twenty-three of 54 metropolitan areas grew by more than 20 percent (the national average was 13.4 percent for 1960-70), with similar percentages for beltway and non-beltway areas.

A recurrent pattern is for older, smaller eastern and northern cities to be surrounded by suburban beltways (examples include Baltimore, Boston, Buffalo, Cincinnati, Cleveland, Minneapolis-St. Paul, St. Louis, and Washington, D.C.), while the younger, physically larger sunbelt cities have annexed land and have beltways within the central city political jurisdiction (e.g., Houston, Lexington, Lubbock, Memphis, Oklahoma City, and San Antonio).

The fundamental differences between the beltway and non-beltway groups, as well as within the beltway sample based on jurisdictional location, represent an important

finding in the effort to classify the potential effects of a beltway. These differences and measures that correlate with beltway location require that the analysis be extended to include other independent forces on development patterns. Only then can one determine whether the existence or location of a beltway is responsible for vast differences in city growth rates, socioeconomic health, and development patterns.

A MULTI-VARIATE ANALYSIS OF BELTWAY INFLUENCE

Multiple regression analysis provides some limited evidence that beltways have a relationship with metropolitan development patterns, even after accounting for other factors. However, these effects are not evident for all possible impacts. Where there were statistically significant effects, they were not large, nor were they necessarily consistent over time. Significant effects appear to be related more to beltway location and the number of interchanges than to the mere existence of a beltway, suggesting that beltways influence the distribution of economic activity and land use within metropolitan areas rather than growth per se.

Of note are the findings of beltway impacts on the distribution of manufacturing employment, on the workplace of the suburban labor force, and on recent trends in central city wholesale and selected services employment. The length of a beltway appears to have some influence on travel patterns in metropolitan areas, increasing vehicle miles traveled per capita. There also was evidence of a slight, one time effect on metropolitan area population growth during the 1960s, but not the 1970s.

Factors that generally provided a better explanation of urban growth and the distribution of population and economic activity included differences in city age, regional location, land area and annexation trends, the proportion of total SMSA population living in the political jurisdiction of the central city, and population density. The location and age of a beltway is a result rather than the cause of such factors in most cases.

In presenting the results of the regression analysis, beltways' effects on overall metropolitan population and employment growth are described first, followed by the distributional effects within metropolitan areas.

BELTWAYS' GROWTH INDUCING EFFECTS

The overall rate of metropolitan population and employment growth (in several categories of employment) was generally higher in beltway metropolitan areas during the 1960-70 or 1967-72 time period than in non-beltway areas, but this pattern reversed itself during the more recent years (see Table 3.10). Multiple regression analysis is required to determine the influence beltway presence or particular characteristics had in the individual relationships.

TABLE 3.10. COMPARISON OF THE PRESENCE OF A BELTWAY AND SMSA GROWTH RATE

		No Beltway		Beltway	
		Mean	Standard Deviation	Mean	Standard Deviation*
Population Growth	1960-70	28	20	34	27
	1970-77	10	9	5	9
Manufacturing Employment Growth					
	1967-72	10	29	12	26
	1972-77	8	17	4	21
Retail Employment Growth					
	1967-72	30	15	32	21
	1972-77	22	8	17	11
Wholesale Employment Growth					
	1967-72	17	11	19	15
	1972-77	14	10	10	10
Selected Services Employment Growth					
	1967-72	46	26	55	33
	1972-77	34	58	20	11

*Differences significant at the .05 level.

Population Growth

Hypothesis: **Beltways do not have any effect on the overall rate of metropolitan population growth.**

Obviously, a beltway is not the main determinant of the population growth rate of a metropolitan area. The growth of employment and the demographic structure of the region are far more important. By improving accessibility within a region, however, a beltway might result in some new economic activity that did not represent a transfer from an alternate location within the same metropolitan area. Certain manufacturing or distribution firms or individuals who need good auto or truck accessibility to a large area might be influenced to select a particular metropolitan area by the presence of a beltway.

Variables that one would expect to affect the rate of population change include: basic manufacturing employment; age of the central city—a measure of growth cycles; an index of regional growth patterns such as cold weather—a good correlate for industrial and population moves to the sunbelt; principal arterial mileage per capita—an index of the quality of the highway and freeway network; and measures of beltway characteristics (degree of suburban location, mileage, and interchange density - number of interchanges per mile).

Beltway location was significant in only one equation, the 1960-70 change in SMSA population, with a positive relationship and fairly small coefficient. This finding and the absence of a similar effect in the 1970-77 equation suggest that a beltway may have had a minor positive influence on metropolitan area population growth in the 1960s, but none thereafter. Neither beltway mileage nor interchange density was significant in either equation.

Table 3.11 illustrates the explanatory variables for the 1960-70 SMSA population growth equation; increase in manufacturing employment, suburban beltway location, and city age were significant in addition to the constant. A second equation, substituting beltway distance from the CBD for beltway location, showed only change in SMSA manufacturing employment as significant, a factor unrelated to the beltway indicators.

TABLE 3.11. REGRESSION EQUATION FOR POPULATION

Dependent variable = percent change in population SMSA 1960-1970

$R^2 = 0.71$
54 observations

Independent Variables (F score cutoff = 1.0)	Coefficient	Statistical Significance (level)
Percent Change in Manufacturing Employment, SMSA 1967 - 1972	.5920	.000*
Percent of Beltway Located in Suburbs	.0021	.017*
City Age Index	-.0279	.008*
Principal Arterial Mileage Per 1000 Persons, SMSA 1975	-.2030	.161
Transit Vehicles Per 1000 Persons, SMSA	.0017	.265
Interchanges Per Mile of Beltway	-.0842	.306
Constant	.3646	.001*
Equation		.000

*Significant at the .05 level.

For the 1970-77 time period, SMSA population growth was influenced by a greater number of factors. The city age index and cold weather had the strongest influence; manufacturing employment growth and arterial mileage per capita were also significant. This shift suggests that during the 1970s, while manufacturing growth remained important, the growth of younger southern and western metropolitan areas became much stronger. Based upon the models developed, the hypothesis of no beltway effect on metropolitan population growth must be rejected. However, there was no systematic or consistent effect, but rather a possible one time positive effect in the 1960s.

Manufacturing Activity

Hypothesis: **Beltways do not stimulate the rate of growth of metropolitan manufacturing activity (basic employment, value added, and capital investment).**

Three measures of manufacturing activity were analyzed for a beltway effect: percent change in SMSA manufacturing employment; percent change in manufacturing value added, tested to determine whether beltways are related to productivity changes not reflected in employment; and manufacturing capital investment, an indicator of investment in new plants. Other influences on metropolitan manufacturing activity that were considered in the multiple regression models included: city age and cold weather, judged as good indicators of regional shifts; changes in per capita income and the number of households as indexes of the strength of the local market; and arterial mileage per capita and the proportion of total regional VMT on freeways as measures of accessibility. The previously defined beltway indicators of location, mileage, and interchange density were used. For the two manufacturing employment models, city age was the only significant influence upon 1967-72 changes, and arterial mileage and per capita income changes were the only significant factors in the 1972-77 model. Neither of the beltway indicators nor a separate analysis using beltway distance from the CBD showed any beltway influence on metropolitan manufacturing employment.

In conclusion, there is no systematic beltway influence on regional manufacturing employment growth, indicating that beltways have not made metropolitan areas more competitive after accounting for other influences.6 There were no high correlation coefficients between beltway characteristics and otehr variables, so no evidence that multicollinearity masked beltway effects. Regression models for value added and capital investment also yielded no evidence of a beltway influence on metropolitan growth rates; the models derived for value added were similar to those for employment. No significant and reliable model was derived from the data base for manufacturing capital investment. Thus the null hypothesis of no beltway effects cannot be rejected based on the evidence at hand.

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6 The Brookings Institution found a small positive relationship between the beltway measured as the percent of arc actually built and metropolitan employment growth, but only significant at the 80 percent confidence level. Equations derived by the staff are being re-estimated as this report is written (Kathy Bradbury, personal communication).

Employment Growth

Hypothesis: **There is no difference in the overall rate of metropolitan non-basic employment growth that can be attributed to a beltway.**

Retail Employment. While SMSA retail trade and trade jobs would not be expected to be greatly influenced by a beltway, being mostly influenced by population and income levels, accessibility improvements resulting from a beltway could provide an inducement to select a particular SMSA for major shopping trips originating outside the SMSA. While an early run on the 1972-77 data using a subset of the sample suggested some possible effect, analysis of the entire 54 metropolitan area sample indicated that percent increases in population and manufacturing employment were the only significant indicators of retail employment growth.

Wholesale Employment. Wholesaling, closely related to distribution, often requires large amounts of land, and wholesalers consider vehicular accessibility important in location decisions. While some wholesaling activity is located to serve a particular metropolitan area and thus the effect of a beltway would be distributional, other decisions are based upon a desire to serve a larger market area, and thus might be influenced by the accessibility gains for inter-regional movement that could result from a beltway.

Other factors which one would expect to influence the rate of growth in this sector would be the growth in basic manufacturing employment, the population growth rate, and the percent increase in per capita income. Regional factors are city age and cold weather, as well as accessibility measures of per capita arterial mileage and the beltway indicators.

For the 1967-72 time period, percent increase in population was the primary indicator of metropolitan wholesale employment increases. For 1972-77, a complex joint effect of manufacturing employment growth, city age, the distance of a beltway from the central business district, and the lack of a good arterial highway system explains much of the variation in wholesaling employment (see Table 3.12). Sign shifts for several variables between the correlation matrix and the regression coefficients, including arterial mileage per capita, income growth, population growth, and beltway distance from the CBD, suggest that multicollinearity and joint effects make it difficult to separate out influences of individual independent variables. Specifically, correlations of -.70 between city age and metropolitan population growth and .68 between beltway distance and interchange density tend to confirm this. While the regression model suggests that a beltway farther from the core would stimulate wholesale employment, the correlations suggest the opposite, and in fact wholesale employment increases were higher in non-beltway SMSAs. However, in conjunction with differences in city age and manufacturing employment, the influence of beltway distance could be positive and significant. Therefore, the null hypothesis of no beltway effect must be rejected for the 1972-77 period.

Beltways appear to have had a positive, significant effect on wholesale employment growth after accounting for other influences, with the greater impact occurring where beltways were farthest from downtown.

TABLE 3.12 REGRESSION EQUATION FOR WHOLESALE EMPLOYMENT

Dependent variable = percent change in wholesale employment SMSA 1972-77

$R^2 = .53$
54 observations

Independent Variables	Coefficient	Statistical Significance (level)
Percent Change in Metropolitan Area Population, 1970-77	-.0330	.872
Percent Change in Manufacturing Employment, SMSA, 1972-77	.3143	.000*
Annual Increase in Per Capita Income, SMSA, 1969-74	-.0111	.548
City Age Index	-.0154	.029*
Degree Days - Cold Weather	-.0001	.489
Principal Arterial Mileage Per 1000 persons	-.1903	.044*
Beltway Mileage	-.0016	.057
Interchanges per Mile of Beltway	-.0600	.074
Distance of Beltway from CBD	.0119	.044*
Constant	.3801	.047*
Equation		.000*

*Significant at the .05 level.

Selected Services Employment. Analysis of beltway influence on variation in metropolitan changes in selected services employment indicated no statistical relationship either for the 1967-72 or 1972-77 period.

BELTWAYS' DISTRIBUTIONAL EFFECTS

How beltways potential have affected the distribution of population, residential development, manufacturing activity, retail sales and employment, and wholesale and selected services employment was examined to determine whether shifts in activity within metropolitan areas is related to any of the beltway attributes. Impacts on commuting patterns and workplace and residential location decisions also were analyzed to see whether a change in behavior might suggest a future land use impact. The results, presented below, illustrate how a beltway becomes a relatively unimportant factor in explaining the distribution of population and economic activity after accounting for other influences.

Population Growth

Hypothesis: Beltways do not have any effect on central city population growth.

A beltway is more likely to influence the direction or location of growth that occurs within a metropolitan area, considered a transfer, rather than to function as a growth inducer. One way of assessing the locational effect of a beltway is to review growth of central cities in comparison to their overall metropolitan area growth rate, and to examine whether there are differences based on the location of the beltway.

Table 3.13 illustrates the results of a comparison of population growth rates broken down into subgroups by beltway location. In 1970, there were only 19 completed beltways; by 1977, there were 27.

Overall, central cities containing part or all of a beltway grew at a faster rate than did the total SMSA, while those central cities without beltways grew at a lesser rate. Cities in metropolitan areas containing a suburban beltway declined slightly. During 1970-76, all groups of central cities showed a decline in average population with the exception of central cities containing an urban beltway. The differences in population growth rate were statistically significant at the .05 level or better for central cities during the 1970-76 time period.

The vast differences in population growth between cities containing beltways and those surrounded by a suburban beltway cannot be attributed totally to the location of the beltway; there are significant differences between the two groups in terms of urbanized area, the amount of vacant land in the central city, and the city's ability to annex additional land, as reported in the previous section. Because of these and other differences, it is important to look at all the other factors that together influence population growth.

Based on theory and experience, key variables that one would expect to affect the rate of population change for a central city include: (1) changes in area of jurisdiction, particularly annexations in the case of central cities; (2) changes in basic manufacturing employment; (3) age of the central city—a measure of the growth cycle; (4) an index of regional growth patterns such as cold weather—a good correlate for industrial and population moves to the Sunbelt; (5) the annual rate of increase in per capita income—a measure of economic vitality; (6) principal arterial mileage per capita—an index of the quality of the highway and freeway network; (7) quality of transit service, approximated by the vehicles per capita; and (8) measures of beltway characteristics (degree of suburban location, mileage, interchange density, and distance from the CBD).

TABLE 3.13. COMPARISON OF THE PRESENCE OF A BELTWAY AND PERCENTAGE CHANGE POPULATION, 1960-70 AND 1970-77

	1960-1970			1970-1977[1]		
	SMSA	Central City	Obser-vations	SMSA	Central City*	Obser-vations
No Beltway	28	21	35	10	0	27
Beltway	34	16	19	5	-4	27
Central City	23	40	4	10	5	8
Mixed Jurisdiction	36	42	5	5	-4	8
Suburban	36	-2	10	3	-10	11
Average	30	19		8	-2	
TOTAL			54			54

1. Central City 1970-1976

*Differences significant at the .05 level.

Neither beltway location, beltway mileage, nor interchange density were significant in either the equation for 1960-70 or 1970-76 changes in central city population growth. The percent change in manufacturing employment was significant in both equations, confirming the relationship between basic employment trends and population growth; people follow jobs. The city age index was significant and negative for both equations. This seems to suggest a city growth cycle. In fact, the older cities tend to be smaller and have less vacant land, thus it is reasonable to expect less population growth. Unless a city can annex additional land, which few older cities can, it is virtually impossible for population growth to occur during a period of declining average household size.

The change in land area was the most important explanatory variable in the equation of 1960-70 central city population growth, confirming that those central cities that annexed surrounding suburbanizing areas were the fastest growth centers. The percent change in land area and the city age index together explain nearly all the variance in central city population growth, 1960-70. In the 1970-76 central city regression equation, city age explains about four-fifths of the total variance in population growth but is not significant by itself once other variables are introduced. This is a result of apparent multicollinearity between city age, central city manufacturing employment growth 1967-72, and cold weather. The percent change in central city manufacturing employment, arterial mileage per capita, and cold weather were significant but with small effects on R-square. A separate model substituting beltway distance from the CBD yielded similar findings; no apparent beltway influence.

This analysis suggests that during the 1970s, while manufacturing growth remained important, the regional differences expressing the growth of younger southern and western metropolitan areas and cities with better weather and highway systems became much stronger.

In conclusion, there is little evidence that beltways have any consistent or significant effects on central city population growth rates. The apparent beltway relationship with population growth disappears when more significant differentiating characteristics including manufacturing employment changes, city age, and change in land area are introduced into a regression analysis.

Residential Development Patterns

Hypothesis: The proportion of new SMSA housing built in the central city is not affected by development of a beltway.

If a beltway improves accessibility within the metropolitan area, one would expect it to affect housing development. When a beltway is built in the suburbs, residential development should follow, and the proportion of new housing built in the suburbs should be higher than in metropolitan areas with no beltway, or with a beltway located within the jurisdiction of the central city. Prior research and location theory both suggested that a beltway should have such an effect. To test this expected shift in housing location, an index of the ratio of the percent change in housing in the SMSA to new housing in the central city was derived; thus, figures over 1.0 indicate a faster proportional increase in SMSA housing, and figures below 1.0 indicate that the rate of housing growth is proportionally greater in the central city. Table 3.14 illustrates the differences between cities.

TABLE 3.14. COMPARISON OF THE PRESENCE OF A BELTWAY AND THE RATIO OF SMSA/CENTRAL CITY RATE OF CHANGE IN NEW HOUSING UNITS, 1960-1970

	Ratio	Number of Observations
No Beltway	3.15	32
Beltway	1.50	22
Central City	.76	4
Mixed Jurisdiction	.69	7
Suburban	2.28	11
Average	2.48	
TOTAL		54

Historical beltway location is associated with residential development patterns because of fundamental differences in cities. The rate of increase in housing units was faster in the central city where a beltway is located within the central city, and conversely, a suburban beltway is related to faster growth of housing in the suburban communities. Given the differences between beltway and non-beltway central cities, this is not surprising and cannot be considered as evidence of the role of beltways in housing development. Beltways generally were built in less developed areas on the urban fringe, which was where growth would have occured in the absence of a beltway.

A second finding is that the ratio of suburban housing development to central city housing development is greatest in non-beltway metropolitan areas, greater even than the ratio in metropolitan areas with suburban beltways. Based on this, one might surmise that beltways do not encourage suburbanization.

Other factors potentially affecting the ratio of new housing units in the SMSA to those in the central city include: the rate of change in metropolitan population, the proportion of the suburban labor force employed in suburban communities, city age, the amount of vacant land in the central city, total freeway mileage, the freeway utilization/capacity ratio (vehicle miles per capacity mile—measuring the influence of congestion on development), and the beltway indicators.

A regression analysis of these variables yielded no equation that was statistically significant at the .05 level or better. Thus, there does not seem to be any systematic relationship between the central city's share of regional housing production and the expected indicators. Likewise, there does not seem to be any direct relationship with the existence of a beltway.

In summary, it was not possible to determine what the important influences were with the available data base or to identify how beltways work with other factors to produce this outcome. Consequently, the null hypothesis of no beltway influence cannot be rejected.

Manufacturing Activity

Hypothesis: **Beltways have no effect on the distribution of manufacturing activity (basic employment, value added, and capital investment) within metropolitan areas.**

Employment. Prior beltway analyses have concentrated on analyzing effects on industrial location; generally concluding that a beltway had a strong effect on industrial location, but little evidence was presented to show whether this represented new growth or simply a transfer within the area. Table 3.15 summarizes the results of analysis of variance tests on the average rate of change in manufacturing employment.

The average percent change in manufacturing employment was -4 percent between 1967 and 1972 for central cities in SMSAs with beltways in comparison to a 9 percent increase in central cities in SMSAs without beltways. Differences were also statistically significant within the beltway group, suggesting an effect potentially attributable to different beltway locations. Central cities with an urban beltway had an average manufacturing employment growth rate of 28 percent, while manufacturing employment in central cities with a beltway in the surrounding suburbs declined by 23 percent between 1967 and 1972. While only a bi-variate analysis, this discrepancy may indicate a relationship between the location of a beltway and the distribution of manufacturing employment growth within the metropolitan area. All things being equal, it appears that a suburban beltway has a negative relationship with central city manufacturing employment growth.

TABLE 3.15. COMPARISON OF BELTWAY PRESENCE AND PERCENTAGE CHANGE, MANUFACTURING EMPLOYMENT, 1967-72 AND 1972-77

	1967 - 1972			1972 - 1977	
	SMSA	Central City*	Obser-vations	SMSA*	Obser-vations
No Beltway	10	9	29	8	27
Beltway	12	-4	25	4	27
Central City	20	28	6	17	8
Mixed Jurisdiction	14	-3	8	-1	8
Suburban	4	-23	11	-2	11
Average	11	3		6	
TOTAL			54		54

*Differences significant at the .05 level.

There are other influences on changes in manufacturing employment for 1967-72, and multi-variate regression equations were estimated for 1967-72 central cities. City age and cold weather, expressed in degree days, were judged good indicators of regional shifts in manufacturing location, while changes in per capita income, the number of households, and the area of jurisdiction were included as indexes of the strength of the local market. Arterial mileage per capita and the proportion of total regional VMT on freeways show accessibility, and the previously defined beltway measures of location, mileage, and interchange density were used to assess the beltway influence.

The apparent negative relationship between beltways and central city manufacturing employment increases is confirmed by the multi-variate regression model, with a suburban beltway location as the second independent, statistically significant variable (see Table 3.16). The city age index served as the primary indicator of manufacturing employment trends in central cities for the 1967-72 time period, also with a negative sign. Beltway location explained seven percent of the variation in employment trends; total R-square of the model was .59. Other variables in the equation were not statistically significant. Thus, for central cities between 1967 and 1972, the model suggests that younger central cities without beltways or with central city beltways had the largest increases in manufacturing employment, while older central cities and central cities with suburban beltways had the smallest growth or posted declines in employment. As the 1977 Census of Manufacturing data for cities have not yet been released, the above model could not be run for the second time period.

A separate model run with beltway distance from the CBD substituted for beltway location yielded an equation with city age the only statistically significant variable. The signs and coefficients of other variables remained similar, and all beltway variables had a negative sign although they were not statistically significant.

TABLE 3.16. REGRESSION EQUATION FOR MANUFACTURING EMPLOYMENT

Dependent variable = percent change in manufacturing employment Central City, 1967-1972

R^2= 0.59
54 observations

Independent Variables (F score cutoff = 1.0)	Coefficient	Statistical Significance (level)
Percent Change in Housing Units, Central City, 1960 - 1970	.0027	.114
Percent Change in Area, Central City, 1960 - 1970	-.0117	.254
Annual Increase in Per Capita Income, Central City, 1969 - 1974	.0465	.181
City Age Index	-.0523	.001*
Principal Arterial Mileage Per 1000 Persons, 1975	-.4079	.052
Percent of Beltway Located in Suburbs	-.0020	.012*
Constant	.0968	.759
Equation		.000*

*Significant at the .05 level.

In conclusion, manufacturing employment is stable or declining in older eastern and midwestern cities where the beltways are likely to be located in suburban communities rather than within the central cities. However, in conjunction with city age, the existence of a suburban beltway did correspond to a significant weakness in central city manufacturing employment during the 1967-72 time period.

Lack of vacant industrial land in smaller central cities and differences in wage rates between cities are other factors that relate to manufacturing employment changes and have a high correlation with a suburban beltway location. For example, the correlation between vacant central city land and manufacturing employment was -.56; this variable was not included in the model because it was available for only a limited sub-sample of cities. It also measures all vacant developable land, not just industrial land, and thus is not an accurate indicator of real opportunities for industrial development.

Value Added

To further confirm the assessment of the relationship between beltways and manufacturing employment, a separate analysis of variance and regression series was developed for manufacturing value added, a measure of output productivity in contrast to employment which examines a major manufacturing input. As was the case for employment, differences were greater when stratifying by beltway location than when comparing beltway and non-beltway metropolitan areas. For example, comparisons of central city manufacturing value added between 1967 and 1972 showed statistically significant differences, with non-beltway and central city beltway areas exhibiting a greater growth rate than suburban and mixed jurisdiction beltway cities, 52 and 50 percent in comparison with 15 and 34 percent respectively. The regression equations were similar to those for manufacturing employment. For the 1967-72 central city model, city age explained much of the variance in manufacturing value added as it did in the manufacturing employment regression equation. Beltway mileage rather than beltway location was the second most important explanatory variable entering the equation with a negative coefficient. This is illustrated in Table 3.17. No other variables were statistically significant.

TABLE 3.17 REGRESSION EQUATION FOR MANUFACTURING ACTIVITY

Dependent variable = Percent Change in Value Added by Manufacturing Central City, 1967-1972

$R^2 = 0.50$
54 observations

Independent Variables (F score cutoff = 1.0)	Coefficient	Statistical Significance (level)
Percent Change in Number of Housing Units, Central City, 1960-1970	-.3552	.061
Annual Increase in Per Capita Income, Central City, 1969-1974	5.8252	.222
City Age Index	-10.7209	.000*
Beltway Mileage	-.3659	.020*
Constant	62.1286	.125
Equation		.000*

*Significant at the .05 level.

These findings confirm the possibility of a relationship between manufacturing activity in central cities between 1967 and 1972 and beltways. In the case of employment, this was expressed best by the beltway location variable (i.e. a suburban beltway location has a negative relationship with central city manufacturing employment). For manufacturing value added, beltway mileage was the significant factor. In this equation, the longer the beltway, the greater the negative association with central city growth in manufacturing value added. Multicollinearity between beltway location and beltway mileage explains why either could be an important factor. Moreover, as beltway mileage is not as closely related to fundamental metropolitan and city differences as is beltway location, its significance is particularly noteworthy and suggestive of an unbiased adverse beltway effect on manufacturing activity.

The suburban beltways, because they are in larger metropolitan areas, tend to be longer. However, a long suburban beltway does provide a greater number of potential industrial sites, a possible incentive for development decisions and moves from central cities to suburban communities. Given these findings, the hypothesis of no beltway effect on the distribution of manufacturing activity must be rejected.

Capital Investment

Whether beltways show any relationship with manufacturing capital investment also was examined. However, neither the analysis of variance nor the regression equations detected any significant beltway effects. The regressions did not produce a reliable model of changes in central city manufacturing capital expenditure; no equation was significant at the .05 level or better.

Retail Sales

Hypothesis: Beltways and their characteristics have no discernible effect on changes in central city or central business district retail sales.

Retail sales clearly are an important indicator of economic activity and fiscal health. Retail sales growth stimulates employment and generates sales taxes, of which a significant portion is returned to local government in most cities or counties. The development of large shopping centers has contributed to the decline of older shopping districts in some regions. When new developments are established outside the city in which the declining center is located, the results are a transfer of economic activity and sales taxes from one jurisdiction to another, which can compound the effects of downtown decline. As shopping center developers prefer to locate next to major limited access highways which provide excellent accessibility, new highways often are cited as causes of such development. Although beltways are favored locations for major commercial developments and shopping centers, they may not increase significantly the number or success of suburban centers which are built to serve a market whose size may not be affected by a beltway. Prior beltway studies differed in their conclusions regarding effects on retail activity, but small sample sizes and data for only a few time periods limited the conclusions that could be drawn.

A central city's share of metropolitan sales could be affected by the location and attraction of a beltway. Likewise, a beltway, by improving access to suburban type shopping centers, could have an adverse effect on central business district retail activity. Differences in central city retail sales growth are significant when compared by beltway location for both 1967-72 and 1972-77. In central cities with beltways, the increase in retail sales was similar to that of the SMSA; where the beltway was located in suburbs, central cities' retail sales lagged significantly even though the SMSA growth rate was similar. Table 3.18 illustrates this.

TABLE 3.18. COMPARISON OF BELTWAY PRESENCE AND PERCENTAGE CHANGE IN RETAIL SALES, 1967-72 AND 1972-77

	1967 - 1972			1972 - 1977		
	SMSA	Central City*	Obser-vations	SMSA*	Central City	Obser-vations
No Beltway	65	44	29	65	49	27
Beltway	69	38	25	56	39	27
Central City	72	71	6	68	65	8
Mixed Jurisdiction	66	37	8	59	38	8
Suburban	68	21	11	48	23	11
Average	67	41		61	45	
TOTAL			54			54

*Differences significant at the .05 level.

Table 3.19 shows the average change in CBD retail sales for 25 non-beltway and 24 beltway SMSAs. There were few differences for the 1967-72 time period. While the 1972-77 differences were greater, the beltway/no beltway difference was not statistically significant because of great variance within the groups. Table 3.20 shows relatively similar proportions of CBDs increasing and decreasing in sales for the beltway and non-beltway areas and confirms the lack of an apparent beltway influence. Interestingly, there appears to be an inverse relationship between central city and CBD sales trends. CBD sales were stronger in slower population growth central cities lacking beltways. This suggests that faster growing areas have been more attractive for developers of new retail space which is competitive with existing retail development, an intuitively logical finding.

Because of large differences in the geographic definition of particular major retail centers (MRCs) between the 1972 and 1977 Censuses of Retail Trade, trends in sales of specific centers could not be analyzed reliably in relation to distance from a beltway. Such trends were analyzed in the detailed case studies.

TABLE 3.19. COMPARISON OF BELTWAY PRESENCE AND PERCENTAGE CHANGE IN CENTRAL BUSINESS DISTRICT RETAIL SALES, 1967-72 AND 1972-77

	1967-72	1972-77	Number of Observations
No Beltway	-4.1	2.4	25
Beltway	-6.0	-3.4	24
Central City	-9.2	-6.0	7
Mixed Jurisdiction	-8.2	-10.7	3
Suburban	-2.2	3.5	10
Average	-4.8	-.4	
TOTAL			49

Note: Differences are not statistically significant at the 0.05 level.

Many of the factors that influenced manufacturing and population growth also would be expected to affect retail sales patterns. Based on retail market theory and prior research by Kain and others, variables included in the regression analysis were (1) the rate of increase in population (or households when this better indicator is available), (2) the rate of change in per capita income, and (3) employment growth in manufacturing and in selected services. The beltway indicators and arterial mileage per capita were used as accessibility measures.

In the model for 1967-72 changes in central city retail sales, five variables and the constant were significant; the percentage change in housing units (and therefore households) accounted for most of the variation in these sales. Other significant variables were: the percent change in selected services employment, the number of transit vehicles per 1,000 persons (negative), the percent change in per capita income, and arterial mileage per capita. All variables had the expected sign; the negative relationship with good transit reflects the much higher population growth in sun belt cities which lack good transit. That is, good transit is inseparable from major characteristics of cities which are really the influencing factors. The lack of a beltway influence is notable considering the strong relationship between changes in retail sales and beltway location. Clearly, the key influence on retail sales was household growth, but increases in selected services employment and relatively good arterial highway systems also were important.

TABLE 3.20. COMPARISON OF BELTWAY PRESENCE AND INCREASES IN CENTRAL BUSINESS DISTRICT RETAIL SALES, 1967-72 AND 1972-77

	Increases 1967-72		Decreases 1967-72	
Beltway	Atlanta	Louisville	Buffalo	Omaha
	Baltimore	Lubbock	Columbus	Raleigh
	Boston	Milwaukee	Dallas-Ft. Worth	Rochester
	Cincinatti	Washington DC	Indianapolis	San Antonio
			Minneapolis-St. Paul	Toledo
			Nashville	Wichita
Non-Beltway	Charlotte	Portland	Akron	Madison
	Chattanooga	Richmond	Albuquerque	Sacramento
	Jacksonville	Salt Lake City	Dayton	San Diego
	Kansas City	Spokane	Fresno	Seattle
	New Orleans	Tampa	Grand Rapids	Syracuse
	Pittsburgh	Tulsa	Knoxville	Tucson
			Little Rock	

	Increases 1972-77		Decreases 1972-77	
Beltway	Boston	Louisville	Atlanta	Omaha
	Cincinnati	Milwaukee	Baltimore	Raleigh
	Dallas-Ft. Worth	Minneapolis-	Buffalo	Rochester
	Houston	St. Paul	Columbus	Toledo
	Indianapolis	San Antonio	Lubbock	Washington DC
	Wichita		Nashville	
Non-Beltway	Fresno	Sacramento	Akron	Kansas City
	Grand Rapids	Salt Lake City	Albuquerque	Knoxville
	Little Rock	San Diego	Charlotte	Richmond
	Madison	Seattle	Chattanooga	Tampa-St. Petersburg
	Pittsburgh	Tulsa	Dayton	Syracuse
	Portland		Jacksonville	Tucson

In the model for 1972-77 central city changes in retail sales, only the percent change in central city population was significant. Table 3.21 illustrates these models; the two left columns present the data for the 1967-72 model, the right columns the 1972-77 model. A separate model using beltway distance from the CBD instead of beltway location yielded a model with three significant variables; central city population change, and manufacturing and selected services employment changes in the central city. Again, no beltway indicator was significant.

Models developed for changes in central business district retail sales were weak, with R-square values of .26 and .20 in comparison with the R-square values of .77 or more for the central city retail sales models. Neither equation was statistically significant. Only one variable explained a significant portion of the variation in CBD sales in each time period, changes in per capita income in the central city for 1967-72 and changes in central city selected services employment for 1972-77. No beltway influence was detected. Table 3.22 summarizes the CBD models for 1967-72 and 1972-77.

In order to eliminate possible influences of central city growth rates, a separate analysis was conducted of changes in the ratio of central city to SMSA sales from the 1967-72 to 1972-77 time periods. This too showed no evidence of any beltway effect. The key influence and only significant variable in the model was change in the population ratio between central cities and SMSAs. The constant was significant, and city age (negative coefficient) was the only other variable that even approached a significant level of explanation of changes in the retail sales ratio.

In conclusion, regression models for trends in central city and CBD retail sales showed no evidence of beltway effects in either the 1967-72 or 1972-77 time periods. Thus, there is no basis for rejecting the hypothesis of no beltway effect on retail sales patterns.

Employment

Hypothesis: There is no difference in central city employment growth that can be attributed to beltway existence or characteristics.

Retail Employment. Trends in retail employment are another significant indicator of central city economic vitality. Not only is the retail sector an important source of jobs and income, but retail sales and employment represent secondary effects of central city basic and service employment patterns. The overall rate of SMSA retail employment growth would not be expected to be affected by a beltway, but a beltway could have significant distributional effects on central city retail employment patterns. Table 3.23 illustrates this. There were no differences between beltway and nonbeltway SMSAs during the 1967-72 period. During the 1972-77 period, the non-beltway SMSA sample had a faster rate of increase in retail employment, reflecting the greater population growth in such regions.

TABLE 3.21. REGRESSION EQUATIONS FOR CENTRAL CITY RETAIL SALES

Dependent variable =	percent change in retail sales, central city, 1967-72		Dependent variable =	percent change in retail sales, central city, 1972-77	
	R^2 = 0.88 54 observations			R^2 = .73 54 observations	
Independent Variables (F score cutoff = 1.0)	Coefficient	Statistical Significance (level)	Coefficient	Statistical Significance (level)	
Percent Change Central City Housing Units, 1960-70	.0056	0*			
Percent Change Central City Population, 1970-76			1.1871	.000*	
Percent Change Central City Manufacturing Employment 1967-72	.1333	.081	.1711	.057	
Percent Change Central City Selected Services Employment	.5707	.000*	.1707	.158	
Annual Increase Per Capita Income, 1969-74	.0519	.013*	.0289	.171	
Principal Arterial Mileage per 1000 persons, SMSA 1975	.2797	.028*	.0306	.826	
Transit Vehicles per 1000 persons, 1976	-.0030	.017*	-.0020	.148	
Beltway Mileage	-.0004	.722	.0012	.202	
Beltway Interchange Density	-.0013	.982	-.0204	.666	
Beltway Location	-.0031	.717	-.0010	.192	
Constant	-.0433	.016*	.3777	.033*	
Equation		.000*		.000*	

*Significant at the .05 level.

TABLE 3.22. REGRESSION EQUATIONS FOR CENTRAL BUSINESS DISTRICT RETAIL SALES

Dependent variable =	percent change in retail sales, CBD 1967-72		Dependent variable =	percent change in retail sales, CBD 1972-77	
	R^2 = .26 50 observations			R^2 = .20 49 observations	
Independent Variables (F score cutoff = 1.0)	Coefficient	Statistical Significance (level)	Coefficient	Statistical Significance (level)	
Percent Change Central City Population	-.0563	.501	-.3153	.665	
Percent Change SMSA Population	.1649	.171	-.3641	.629	
Percent Change Central City Selected Services Employment	.0439	.829	.9688	.034*	
Annual Increase Per Capita Income, 1969-74	.0711	.020*	.0076	.874	
City Age Index	.0258	.167	.0144	.576	
Percent Suburban Residents Working in CBD, 1970	.0060	.510	-.0069	.651	
Principal Arterial Mileage per 1000 Persons	-.0520	.779	-.2109	.486	
Beltway Mileage	.0009	.591	.0023	.437	
Beltway Interchange Density	-.0129	.871	-.1844	.101	
Beltway Location	-.0001	.942	-.0007	.710	
Beltway Distance from CBD	-.0070	.592	.0138	.544	
Constant	-.7694	.010*	-.1250	.761	
Equation		.343		.728	

*Significant at the .05 level.

For central cities, there were no differences between the beltway and non-beltway group during the 1967-72 time period, but there were very statistically significant differences within the beltway group, central cities with internal beltways averaging a retail employment growth of 33 percent, while central cities with suburban beltways averaged a 2 percent loss. This pattern continued during the 1972-77 time period, with 22 percent growth and -6 percent loss for central cities with central city and suburban beltways, respectively.

Other factors are clearly important determinants of the growth rate of retail employment. These include (1) the rate of increase in basic or manufacturing employment; (2) the overall rate of population increase; (3) city age and cold weather, which test for the influence of regional patterns; and (4) several indicators for general accessibility, including arterial mileage and the proportion of total VMT on freeways.

TABLE 3.23. COMPARISON OF BELTWAY PRESENCE AND PERCENTAGE CHANGE IN RETAIL EMPLOYMENT, 1967-72 AND 1972-77

	1967 - 1972			1972 - 1977		
	SMSA	Central City*	Obser-vations	SMSA	Central City	Obser-vations
No Beltway	30	13	29	22	10	27
Beltway	32	11	25	16	5	27
Central City	31	33	6	24	22	8
Mixed Jurisdiction	33	12	8	17	3	8
Suburban	31	-2	11	11	-6	11
Average	31	12		19	7	
TOTAL			54			54

*Differences significant at the .05 level.

Central city retail employment growth from 1967 to 1972 was most clearly related to population growth. The city age index (negative) was not significant. For the 1972-77 time period, the present change in central city population 1970-77 was the only significant variable. Beltway location, its distance from the CBD, and other characteristics were not significant in either equation.

In conclusion, the rate of population increase was the key factor associated with central city retail employment changes during both time periods. Thus the null hypothesis of no beltway effect on both central city retail sales and employment cannot be rejected.

Wholesale Employment. Wholesaling, closely related to distribution, often requires large amounts of land, and wholesalers consider vehicular accessibility important in location decisions. Thus, the existance or location of a beltway could influence locational decisions of wholesalers and therefore wholesale employment.

As Table 3.24 indicates, metropolitan wholesale employment increased 18 percent from 1967-72 and 12 percent from 1972-77. Central city wholesale employment increases averaged only three percent, suggesting that this is becoming primarily a growth activity outside central cities. Significant differences were evident between the rate of growth in central cities incorporating beltways and those surrounded by beltways in suburban communities.

TABLE 3.24. COMPARISON OF BELTWAY PRESENCE AND PERCENTAGE CHANGE IN WHOLESALE EMPLOYMENT, 1967-72 AND 1972-77

	1967 - 1972			1972 - 1977		
	SMSA	Central City*	Obser-vations	SMSA	Central City*	Obser-vations
No Beltway	17	5	25	14	8	25
Beltway	19	2	24	9	-5	21
Central City	20	22	5	18	12	4
Mixed Jurisdiction	21	8	8	10	-2	6
Suburban	15	-12	11	6	-11	11
Average	18	3		12	3	
TOTAL			49			46

*Differences significant at the .05 level.

Other factors which might affect wholesale employment trends include basic employment (manufacturing) trends, changes in per capita income and population, the regional and city age influences, and the standard beltway and arterial mileage indicators. The model for 1967-72 shifts yielded only two significant variables, changes in manufacturing employment and arterial mileage per capita, thus suggesting that central cities with manufacturing growth located in metropolitan areas with good arterial networks had the largest increases in wholesale employment.

For 1972-77 changes, manufacturing employment was again very significant, but population increase and beltway interchange density (negative) also were significant. This is illustrated in Table 3.25. This suggests that many beltway interchanges would have a negative influence on central city wholesale employment trends. The sign of beltway mileage was also negative, while the sign of location was positive, a reversal from the correlation coefficients with wholesale employment. Neither was significant and the coefficients were extremely small. A separate model substituting beltway distance from the CBD for location yielded similar results: an R square of over .80 with manufacturing employment, population growth,

and beltway interchange density significant. The beltway mileage (negative) and distance from the CBD (positive) terms also were significant with smaller coefficients. Again the sign reversal of beltway distance and the close correlation of beltway distance with the other beltway influences suggests multicollinearity and a joint effect of several variables working together to influence the distribution of wholesale employment.

Given the above equations, the hypothesis of no beltway effect on central city wholesaling can be rejected for the 1972-77 period. A suburban beltway with closely spaced interchanges has the potential to attract wholesale and distribution facilities that otherwise might have remained in the central city.

TABLE 3.25. REGRESSION EQUATION FOR CENTRAL CITY WHOLESALE EMPLOYMENT

Dependent variable = percent change in wholesale employment central city, 1972-77

$R^2 = .75$
54 Observations

Independent Variable	Coefficient	Statistical Significance (level)
Percent Change in Central City Population, 1970-76	.7265	.000*
Percent Change in Central City Manufacturing Employment, 1967-72	.1826	.004*
Annual Percent Change in Per Capita Income, Central City, 1969-74	-.0111	.481
City Age Index	-.113	.143
Degree Days - Cold Weather	.0001	.147
Principal Arterial Mileage Per 1000 persons	.0443	.631
Beltway Mileage	-.0009	.147
Interchanges per Mile of Beltway	-.1085	.002*
Percent of Beltway Located in Suburbs	.0009	.090
Constant	-.0317	.823
Equation		.000*

*Significant at the .05 level.

Selected Services Employment. The service sector, encompassing many employment classifications, includes many office type jobs that are traditionally located in central business districts and represents one of the fastest growing business sectors. Thus, the effects of a beltway on office space location decisions could become evident through analysis of changes in employment in this sector.

In contrast to the small increase in central city wholesale employment from 1967-72, central city selected services employment rose 38 percent—a gain that is 76 percent of the SMSA rate and 12 times the rate of central city wholesale employment. The growth rate in beltway SMSAs was greater than in non-beltway areas for the 1967-72 time period (55 vs. 46 percent); a relation that reversed during the next five years. As with wholesale employment, central cities containing beltways had a faster rate of growth in selected services employment than did the overall SMSA. These differences are shown in Table 3.26.

TABLE 3.26. COMPARISON OF THE PRESENCE OF A BELTWAY AND PERCENTAGE CHANGE IN SELECTED SERVICES EMPLOYMENT, 1967-72 AND 1972-77

	1967-1972			1972-1977		
	SMSA	Central City	Observations	SMSA	Central City*	Observations
No Beltway	46	39	28	34	18	26
Beltway	55	37	25	20	11	23
Central City	50	52	6	23	26	5
Mixed Jurisdiction	52	37	8	23	16	7
Suburban	59	29	11	16	1	11
Average	50	38		28	15	
TOTAL			53			49

*Differences significant at the .05 level.

Other factors which one would expect to influence the rate of growth in selected services employment are the growth of basic manufacturing employment, wholesale employment, the population growth rate, and the percent increase in per capita income. Regional factors are city age and cold weather, as well as accessibility measures including per capita arterial mileage, transit capacity, and the beltway indicators.

The model of 1967-72 changes in central city selected services employment had only two significant variables, city age and percent change in population. Thus, selected services employment was growing fastest in young cities with rapidly growing population. For 1972-77, wholesale employment growth (with a .74 correlation to population growth), beltway interchange density (positive), and beltway distance (negative) were each significant, as illustrated in Table 3.27. This suggests that a beltway at greater distance from the CBD but with few interchanges would be most adverse. Multicollinearity between beltway distance (.68 correlation) and

interchange density is most likely responsible for the interchange density sign shift, which correlation between wholesale and manufacturing employment changes (.71) probably explains the sign shift for manufacturing employment.

TABLE 3.27. REGRESSION EQUATION FOR CENTRAL CITY SELECTED SERVICES EMPLOYMENT

Dependent variables = percent change in selected services employment central city, 1972-77

R^2 - .69
49 observations

Independent Variable	Coefficient	Statistical Significance (level)
Percent Change in Central City Population, 1970-76	.2504	.365
Percent Change in Central City Manufacturing Employment, 1967-72	-.1537	.061
Percent Change in Central City Wholesale Employment, 1972-77	.6340	.012*
Annual Percent Change in Per Capita Income, Central City, 1969-74	.0140	.479
City Age Index	-.0070	.470
Degree Days - Cold Weather	.0001	.926
Percent Suburban Labor Force Working in CBD, 1970	.0054	.322
Principal Arterial Mileage per 1000 Persons	.0965	.418
Transit Vehicles per 1000 Persons SMSA	.0019	.137
Beltway Mileage	-.0001	.969
Interchanges per Mile of Beltway	.1287	.019*
Distance of Beltway from CBD	.0161	.044*
Constant	-.0612	.730
Equation		.000*

*Significant at the .05 level.

Given these findings, the hypothesis of no beltway effect on selected services employment in central cities 1972-77 should be rejected. The model suggests that beltways do attract such employment, and the farther the beltway is from the CBD, the more likely that it will have any adverse effect on central city selected services employment.

Commuting Patterns: Vehicle Miles Traveled

Hypothesis: **Beltways have no significant effects on vehicle miles traveled (VMT) and are unlikely to have effects on energy consumption and air quality.**

The only possible impact of beltways on transportation and commuting that could be examined given available data was the effect on vehicle miles traveled, which functions somewhat as an indicator of energy consumption, and an indirect measure of air pollution. It is not necessarily a measure of air quality; other factors such as wind direction, speed, and topography affect formation of oxidants. Only one previous analysis investigated effects on VMT.[7] It concluded that the beltway did increase average trip distance, but also increased average speed, leading to greater operating efficiency.

It was hypothesized that beltways do not have a significant effect on overall regional vehicle miles traveled (VMT), and that other factors would be the critical determinants. The 1975 daily VMT per 1,000 persons averaged 14,818 miles for the 54 metropolitan area sample, or 14.8 miles per capita per day. Table 3.28 illustrates the breakdown of this between beltway and non-beltway SMSAs and by location of beltway.

TABLE 3.28. COMPARISON OF BELTWAY PRESENCE AND AVERAGE DAILY VEHICLE MILES TRAVELED PER 1,000 PERSONS SMSA 1975

	Vehicle Miles Traveled	Number of Observations
No Beltway	14,683	27
Beltway	14,952	27
Central City	16,301	7
Mixed Jurisdiction	14,825	8
Suburban	14,249	12
Average	14,818	
TOTAL		54

7 Wilbur Smith and Associates, op. cit.

Other factors which could be expected to influence the mileage traveled per capita include population density, the availability of transit as an alternative to driving, the geographic size and population of the metropolitan area, per capita income, cold weather as a regional indicator, the proportion of the suburban labor force working in the CBD, and a group of highway system descriptors, including total freeway mileage, beltway mileage; and interchanges per mile of beltway. Other variables considered were non-beltway freeway mileage, presumably radial freeways; and vehicle miles per capacity mile, a measure of congestion on the arterial network.

The regression model for VMT provides further insights. Five variables were significant: SMSA land area, beltway mileage, non-beltway freeway mileage, the transit index, and pecent change in per capita income (Table 3.29).

TABLE 3.29. REGRESSION EQUATION FOR VEHICLE MILES TRAVELED (VMT)

Dependent variable = daily vehicle miles traveled per 1000 persons

$R^2 = 0.41$
54 observations

Indpendent Variables (F score cutoff = 1.0)	Coefficient	Statistical Significance (level
SMSA Population, 1977	-2.0324	.029*
Per Capita Income, SMSA 1974	135.0663	.276
SMSA Land Area, 1977	.3256	.120
Transit Vehicles Per 1000 Persons, SMSA	-74.5441	.036*
Non-Beltway Freeway Mileage	17.6129	.011*
Beltway Mileage	85.1487	.000*
Constant	7995.8792	.131
Equation		.001*

*Significant at the .05 level.

Based upon this equation, one could conclude that beltway mileage was a significant factor in VMT although only explaining six percent of the variation in VMT. Transit capacity (and presumably transit availability) and the size of the metropolitan area also had substantial effects on average mileage driven. The fact that the average density of the central cities containing beltways was approximately 3,140 persons per square mile in comparison to an average of 4,790 persons for the total sample, and that the land area of the central cities with beltways averaged 370 square miles in comparison to 160 square miles for all cities recalls the magnitude of the fundamental differences in the characteristics of beltway cities. With a large central city, many trips are to scattered non-downtown locations and, therefore, a strong beltway network is required to serve the mobility needs of the area. In such metropolitan areas, one would expect average VMT to have been higher historically

as well as since the beltway was built. The larger the area, the greater the beltway mileage is for a complete beltway, thus the strong relationship between beltway mileage and vehicle miles traveled.

The true effects of a beltway on VMT would depend on the influence of the beltway on land use. If major multi-use nodes were developed along a beltway, such a network could reduce VMT by concentrating some residence and workplace locations. However, if beltway oriented land use developments are scattered and result in a shift of mode from transit to driving, it would seem clear that the beltway increased VMT. Literature on the relationship between new beltways, VMT, and energy use provides no startling insights. According to some analysts, because beltways raise trip speeds and therefore allow for more efficient operating speeds, they reduce energy consumption although increasing VMT. Others see no discernable savings. In any case, the multi-variate analysis of beltway effects on VMT indicate that one should reject the null hypothesis of no effect.

Commuting Patterns: Workplace Location.

Hypothesis: Beltways have no effect on suburban commuting patterns.

How might a beltway affect work locations? Assuming most employed central city residents work in the central city, the proportion of the suburban labor force employed in the central city may be partly a function of the urban transportation network. A beltway may reduce the proportion employed in the central business district (CBD), and a suburban beltway may lower the proportion of suburban residents employed in the central city. By the same hypothesis, a central city beltway could increase the proportion of suburban commuters who work in the central city.

There was little difference between cities studied in the proportion of suburban workers employed in the CBD, either distinguished by beltway/no beltway, or differentiated by location of beltway (see Table 3.30). While there were small differences in the proportion employed in the central cities, these differences are not statistically significant.

TABLE 3.30. COMPARISON OF BELTWAY PRESENCE AND PERCENT OF SUBURBAN LABOR FORCE WORKING IN THE CENTRAL BUSINESS DISTRICT AND ENTIRE CENTRAL CITY, 1970

	Central Business District	Central City	Number of Observations
No Beltway	6.5	37	28
Beltway	6.1	33	23
Central City	5.2	40	5
Mixed Jurisdiction	6.5	34	8
Suburban	6.3	29	10
Average	6.3	35	
TOTAL			51

Other factors besides beltways clearly influence the proportion of suburban commuters who work in the central city. Theory and experience suggests the inclusion of: (1) the ratio of total central city/SMSA employment; (2) transit capacity which one would expect to relate to CBD employment; (3) city age, which relates to city size and other characteristic differences; (4) other accessibility measures, including non-beltway freeway mileage; (5) and the beltway indicators.

The models for these employment percentages did not "explain" a large proportion of the overall variation, demonstrated by an R square value of 0.27 for the CBD model and an R square of 0.20 for the central city model. Key variables in the CBD model were the city age index and non-beltway freeway mileage.

The central city employment model is shown in Table 3.31. Only two variables were significant: the percent of the beltway located in suburban communities, and the amount of non-beltway freeway mileage. Both have negative signs, but explain only 11 and 9 percent of the variation, respectively. Thus, suburban beltways and overall non-beltway freeway networks were negatively related to the percentage of suburban workers employed in the central city. This would relate to the smaller proportion of SMSA population and employment represented by the central cities in the larger SMSAs. Other variables, including city age, proportion of total SMSA employment in the central city, transit capacity, and other beltway indicators, did not have any significant influence. Thus, one cannot accept a hypothesis of no beltway effect on workplace of the suburban labor force. It does not appear that a suburban beltway has an adverse effect on the proportion of suburban workers employed in the central city.

TABLE 3.31. REGRESSION EQUATION OF SUBURBAN LABOR FORCE WORK PLACE

Dependent variable = percent of suburban labor force working in the central city, 1970

R^2= 0.20
51 observations

Independent Variables (F score cutoff = 1.0)	Coefficient	Statistical Significance (level)
Non-Beltway Freeway Mileage	-.0473	.027*
Percent of Beltway Located in Suburbs	-.1210	.005*
Constant	50.0842	0*
Equation		.005*

*Significant at the .05 level.

Intra-Metropolitan Migration and The Suburbanization of Minorities

Hypothesis: Beltways do not affect residential suburbanization rates and the suburbanization of the minority population; nor do they affect suburbanization of employment opportunities.

Proportion of Suburban Movers Relocating From the Central City. Potential measure of a beltway's influence on residential moving patterns is its effect on moves within a metropolitan area. If a beltway influences household location decisions, one would expect to find a higher proportion of households moving to the suburbs in beltway-served areas than where no beltway had been built. The Annual Housing Surveys conducted by the Bureau of the Census and Department of Housing and Urban Development in 1975, 1976 and 1977 provide data for this analysis. Survey coverage is limited, particularly in non-beltway areas; only thirty-six of the 60 Housing Survey areas are included in the 54 SMSA beltway study sample. The study of household location decisions complements the analysis of residential development patterns previously presented.

The average percentage of suburban owners and renters moving from the central city in the last five years was the same for both beltway and non-beltway groups. There were differences based on the location of the beltway (see Table 3.32). While it was hypothesized that a suburban beltway might result in a greater proportion of moves from the central city because of accessibility benefits to the suburban communities resulting from the beltway, the actual relationship was the opposite. Twice the proportion of suburban owners moved out of central cities with beltways than moved out of central cities surrounded by suburban beltways, a statistically significant difference. For renters, the differences were similar but not statistically significant.

TABLE 3.32. COMPARISON OF BELTWAY PRESENCE AND PERCENTAGE OF SUBURBAN MOVERS (OWNERS AND RENTERS) MOVING FROM THE CENTRAL CITY, 1976

	Owners*	Renters	Number of Observations
No Beltway	30	27	13
Beltway	30	25	23
Central City	45	33	5
Mixed Jurisdiction	32	30	6
Suburban	22	20	12
Average	30	26	
TOTAL			36

*Differences significant at the .05 level or better.

Other expected influences on the proportion of suburban movers coming from the central city might be (1) the proportion of SMSA population in the central city; (2) the land area of the central city (the bigger it is, the more likely that the central city contains considerable "suburban type housing" and therefore provides little incentive to move for different housing type); (3) city age (more movement from older cities); (4) the level of per capita property taxes in the central city (push factor); (5) transit capacity; and the accessibility measures of (6) per capita arterial mileage; (7) freeway mileage; and (8) the beltway indicators.

The model for suburban owners, shown in Table 3.33, had an R square of .62 with six variables, although only two were significant in the final equation. The proportion of the SMSA population within the central city explained the majority of the variation. In the final equation, the sign of central city land area was negative, but not significant. A suburban beltway location, with a negative sign, beltway age, radial freeway mileage (negative), and city age (positive although the simple correlation was negative) were the other variables in the equation. Thus, the model for the proportion of suburban owners moving from central cities suggests that this movement is a function of the overall proportion of SMSA population in the central city; and that the central city to suburbs shift is more prevalent in cities without a beltway or with a central city beltway. The existence of a suburban beltway does not seem to have a positive effect on such moves.

Analyzing these results, the effect of beltway location is contrary to what was expected. The strong negative relationship between the proportion of SMSA population in the central city and city age (-.60 correlation coefficient) may have affected the analysis. In older areas with a large proportion of the population already established in the suburbs (and possibly a suburban beltway), the majority of suburban moves are within the suburbs, rather than from the central city to the suburbs. In younger, faster growing areas, there is less of a population base in the outlying suburban communities; therefore, a larger proportion of movers are from the central city.

For the renters model, also shown in Table 3.33, the proportion of SMSA population in the central city, central city land area, suburban beltway location, and radial freeway miles were key explanatory variables; the first three were significant, and the last three had negative signs. The consistent pattern showed a suburban beltway to have a significant but minor negative relationship with the percentage of suburban movers originating in the central city, the same as the owners model, and the opposite of expectation. Unfortunately, multicollinearity among the variables masks relationships. The highest proportion of suburban renters moving from the central city occured in areas where the central city contained a higher proportion of the SMSA population, and also where it was geographically small, has either no beltway or a beltway within its jurisdiction and relatively little radial freeway mileage. The omission of many non-beltway cities from the sub-sample for this analysis, in conjunction with the pattern of more intra-suburban moves in older areas, introduces a degree of bias that limits the significance of the findings. The apparent relationship between beltway locations and such moves is probably more a reflection of the phase of metropolitan development associated with the age of areas, recent growth trends, and other characteristics independent but correlated with beltway jurisdictional location.

TABLE 3.33. REGRESSION EQUATIONS FOR SUBURBAN MOVERS

Dependent variable = percent suburban movers (owners) moving from central city, 1976			Dependent variable = percent suburban movers (renters) moving from central city, 1976	
	R^2 = 0.62 36 observations		R^2 = .50 36 observations	
Independent Variables (F score cutoff = 1.0)	Coefficient	Statistical Significance (level)	Coefficient	Statistical Significance (level)
Percent of SMSA Population in Central City	43.9430	.004*	31.7314	.020*
Central City Land Area, 1977	-.0207	.099	-.0283	.014*
City Age Index	1.0548	.233		
Non-Beltway Freeway Mileage	-.0428	.123	-.0490	.062
Beltway Age	.8692	.101		
Beltway Location	-.2416	.006*	-.0996	.042*
Constant	16.9260	.117	26.2586	.004*
Equation		.000*		.000*

*Significant at the .05 level.

Minority Suburbanization. There are few good indexes available to test whether beltways have any effect on the suburbanization of minorities. Because a beltway improves accessibility between suburbs rather than to downtown, it may discourage the suburbanization of blacks who are more likely to be employed in central cities than in suburban communities. To test for effects on the mobility of black households, the Annual Housing Surveys were analyzed. However, data were available for only 19 SMSAs, including only five without beltways.8

Differences in black moving patterns between beltway and non-beltway areas are not statistically significant (see Table 3.34). Clearly, the proportion of SMSA population that is black is an important influence if not the key influence on black moving patterns. Other potential influences include cold weather and city age, measures of regional differences; the transit capacity; total radial freeway mileage; and the beltway indicators. The regression models for black suburbanization only contained two significant models, the proportion of the metropolitan population that is black, and the transit indicator, associated with older northern and midwestern cities that have fairly high levels of transit service. There does not appear to be any relationship between a beltway and black suburbanization.

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8 A recent more comprehensive analysis of black suburbanization is: Nelson, Kathryn, Recent Suburbanization of Blacks: How Much, Who, and Where Washington) Office of Policy Development and Research, U.S. Department of Housing and Urban Development, Washington, D.C., 1979., p. 94.

TABLE 3.34. COMPARISON OF BELTWAY PRESENCE AND PERCENTAGE OF BLACK SUBURBAN MOVERS (OWNERS AND RENTERS), 1976

	Owners*	Renters	Number of Observations
No Beltway	3.9	5.9	5
Beltway	4.6	7.3	14
Central City	4.9	6.9	3
Mixed Jurisdiction	2.1	4.9	4
Suburban	5.8	8.8	7
Average	4.4	7.1	
TOTAL			19

*Significant at the .05 level.

CONCLUSION AND RECOMMENDATIONS FOR FURTHER RESEARCH

The analysis of growth and economic activity in 54 cities demonstrates that beltways may have had some influence on metropolitan development patterns, confirming findings of previous studies. Where statistically significant relationships occur, they are not large, nor are they necessarily consistent over time, suggesting short term effects. Possible effects appear to be related more to beltway location, mileage, distance from the CBD, or the density of interchanges than to the presence of a beltway, suggesting that beltways influence the distribution of economic activity and land use within metropolitan areas more than they influence the overall competitive advantage of a metropolitan area. Learning why this occurs was an important objective of the case studies, the subject of the next chapter.

Beltways exhibit no statistically significant, consistent relationship with the growth and distribution of population and residential patterns, retail sales or employment patterns, and moving patterns, particularly the suburbanization of minority households (during the 1960s and 1970s in the metropolitan areas studied). The finding of no effect on retail sales patterns contrasts with findings of earlier less complete analyses that concluded beltways do adversely affect central city retailing.[9]

On the other hand, significant relationships exist between a beltway's location and the growth of manufacturing, wholesale, and selected services employment in central cities. The influence of beltway location on the workplace of the suburban labor force and of the length of a beltway on travel patterns, measured as vehicle miles traveled per capita, also was found to be significant. Finally, there was evidence of a slight, one time effect on metropolitan area population growth during the 1960s,

9 Urban Institute, Op. Cit.

and limited evidence of a positive influence on SMSA wholesale employment during 1972-1977.

The results of the statistical analysis are credible and generally consistent with expectations. Overwhelming and consistent effects on development patterns were not expected. The process and form of urbanization is complex, and each community has unique features that do not lend themselves to quantitative analysis of generalized development patterns. Further, multicollinearity between variables and joint effects that could not be separated complicate interpretation of the model results.

The comparative statistical analysis should be viewed as one step of a three step analysis procedure in the study of beltway effects on development patterns, not one that stands alone as a conclusive analysis of beltways. When combined with the literature review and analysis of previous beltway studies and furthered by the individual detailed case studies of eight specific cities, it provides a valuable tool helping to isolate particular impact areas requiring special analysis in the detailed case studies.

The comparative statistical analysis also was restricted by budgetary and time constraints which limited data to public sources published on a systematic basis for cities and metropolitan areas across the country. Thus, state and local data sources were not used, nor were private sources such as the Dun and Bradstreet data on births, deaths, and moves of firms or the F. W. Dodge construction reports on office space and industrial construction.

Further research should be directed particularly toward those areas where potential beltway impacts were identified. The analysis of manufacturing trends in central cities should be updated with new census data as it becomes available. Construction data and the Dun and Bradstreet information on firms also could be used to extend the analysis. Another approach would include surveys of firms in particular metropolitan areas, with questions designed to elicit response on options considered in location decisions, not just the stated reasons for a particular move.

No good measure of office employment trends was included in the statistical analysis. Selected services employment was an approximation. Use of construction data on office space and special industry surveys of new office space would provide better indexes of changing trends and allow development of improved equations.

Finally, improved trip data and time series analysis of travel patterns would be required to be more conclusive as to the effects of beltways on vehicle miles traveled and energy consumption.

Data sources such as those discussed above would allow further development of statistical analyses of beltways influence on development patterns, mobility, and energy consumption. But such analysis must be combined with more detailed analysis of effects in particular areas. No single metropolitan area can be explained by average trends; all are unique, and thus neither this nor any other statistical effort can be used to generalize about the effects of beltways in a way that will respond to the concerns and questions about the impacts in a particular locality.

4. CASE STUDIES

OBJECTIVES

To complement the comparative statistical analysis, the experience of eight metropolitan areas with beltways was investigated. The objective of the case study effort was to discover: the local influences on beltway planning and impacts; the political role of different interest groups in beltway planning and the impact of the belt on these groups; the viewpoint of decision-makers in planning and construction of the beltway; and both successful and ineffective strategies for mitigating adverse impacts and enhancing benefits of beltway construction. The case studies addressed the following questions:

- What factors shaped the evolution of the urban highway system, and what alternatives to beltways, if any, were considered? How valid were early transportation studies, land use plans, and traffic projections?

- What role did beltways have in local land use planning and capital improvement programming?

- How important were beltways in residential, commercial and industrial development decisions?

- What effect did beltways have on downtown development and revitalization efforts?

- What are the socioeconomic, fiscal, and environmental consequences of beltways' land use impacts?

- Are local governments' development policies consistent with national urban and transportation policies? What actions are they taking to maximize benefits and to minimize potential adverse effects that beltways may have on metropolitan areas, and how can the federal government best assist them in these efforts?

Before presentation of the individual case studies, a brief description of methodology is required. This is followed by an overview of the case study cities, a summary of major findings and an analysis of similarities and differences among the case studies. This chapter closes with an assessment of the complementary measures that could be implemented to take advantage of the opportunities beltways provide and to minimize their potential harmful effects. For details, the Case Studies report, a companion volume, should be consulted.

METHODOLOGY

The case study cities were selected to provide a balanced representation of the spectrum of American beltway cities, here defined as cities of over 100,000 people, which include a Standard Metropolitan Statistical Area (SMSA) of less than three million, partially or completely encircled by a limited access, non-toll, circumferential highway. Of the twenty-seven such cities included in the

comparative statistical analysis, eight—Atlanta, Baltimore, Columbus, Louisville, Minneapolis/St. Paul, Omaha, Raleigh, and San Antonio—were chosen for in-depth examination. Several criteria determined this choice, including the size of the SMSA, the growth rate of the central city population, the city's geographic location, its degree of economic distress and retail health, and the availability of early planning documents, previous case studies, and data consistent with that published for other prospective case study areas. Finally, the beltways themselves were examined, to ensure that highways of different ages, lengths, distances from downtown, jurisdictional locations, capacities, and traffic volumes were studied.

Following selection of the case study areas, a profile of each region was compiled from land use and transportation planning documents, economic studies, discussions of the case study regions in current planning literature and statistical data. Review of planning documents revealed the evolution of the concerns of planning officials prior to and during beltway planning. This written record provided a crucial complement to the perceptions of local informants, which often are distorted by time and personal perspective.

Several sources of statistical data were consulted to supplement information gathered from local agencies on the regional economic and social structure and its changes over time. Evaluations of economic distress relied upon three widely used measures. The first of these is the Urban Development Action Grant (UDAG) program index used by the U.S. Department of Housing and Urban Development (HUD) to rank cities of over 250,000 on a 0-7 scale, one point being awarded for each of HUD's six criteria of distress met by a city or county and one for an extremely high incidence of poverty.[1] Four points are required for a city's participation in the UDAG program. HUD also ranks 58 major American cities by need on the HUD City Needs Index, assigning the lowest numbers to the most distressed cities. Finally, the Brookings Institution evaluates regional poverty patterns to determine whether greater privation exists within or outside the central city; a score over 100 on this index indicates increasingly greater hardship within the city, a score under 100 reveals greater hardship in the surrounding areas.

Retail sales data were taken from the U.S. Census Bureau's Census of Retail Trade, formerly the Census of Business. These figures allow a comparison of the shares of regional retail sales garnered by the central city, downtown and major retail centers over time. However, the data are in current dollars; care should be taken in comparing retail performance in different years or between cities in different parts of the country. Further, the Census Bureau has frequently altered their operating definitions of major retail centers and central business districts, creating discrepancies in the data which are noted where modifications significantly distort the economic successes of specific centers over time.

Quantitative descriptions of traffic on the various regional highway networks were provided by the state transportation departments. Commute time and speed data by

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1 U.S. Department of Housing and Urban Development, Pockets of Poverty: An Examination of Needs and Options (Washington, D.C.: Office of Community Planning and Development, May 1979), p. 7.

ethnicity and housing tenure are published by HUD and the Census Bureau in the Annual Housing Surveys for most of the case study areas.

Two-day site visits were conducted in January and February 1980 in each metropolitan area to obtain first-hand information on the role of the beltway in shaping urban development patterns and influencing central city vitality. Interviews with 104 local informants—including officials in the city, county, and regional governments and state transportation departments as well as academics, realtors, bankers, developers, retailers, and representatives of civic organizations and community groups—provided invaluable and contrasting perspectives on local beltway planning and the beltway's regional effects.

Drafts of the case studies were critically reviewed by several local informants in each area and by the federal sponsors of this report. Thus, the case studies integrate the findings distilled from study of planning documents, statistical analysis, several interviews, and a rigorous review process.

OVERVIEW OF THE CASE STUDIES

The eight case studies include both large and small metropolitan areas, with population ranging from 460-570,000 in Raleigh and Omaha to about 1.0 million in Columbus, Louisville and San Antonio and 1.8-2.1 million in Atlanta, Baltimore and Minneapolis/ St. Paul. Many of the central cities have had a declining population base; in some cases growth has been constrained because the city could not annex any land. Others have recorded large population gains since 1969. In terms of geographic area, some of the central cities—Baltimore, Louisville, Raleigh and Omaha—have jurisdiction over 55-78 square miles of land; Minneapolis and St. Paul cover 107 square miles; Atlanta, 131 square miles, Columbus, 180 square miles. Significantly larger than the other cities is San Antonio (263 square miles).

Two of the central cities—Atlanta and Baltimore—are classified among the ten most economically distressed cities nationwide, while Louisville and San Antonio rank 17th and 19th respectively, on the HUD Needs Index. The remaining cities do not suffer from severe economic distress, according to these indicators, although "pockets of poverty" certainly exist and are cause for local concern. Overall, the sample, selected in part on the basis of HUD's Urban Development Action Grant program criterion, reflects the 70-30 percent split in distress versus non-distress characteristics. Table 4.1 presents a comparative summary of statistics used in case study selection.

Turning to the beltways themselves, three lie almost completely within the jurisdiction of the central city (Omaha, Raleigh, and San Antonio); two are "mixed" with only 45-60 percent of their length within the central city (Columbus and Louisville); while the remaining three lie outside the city limits. In the smaller cities, the beltways are short, 13-23 miles in length, and located less than five miles from the central business district (CBD). By contrast, the beltways around the larger cities range from 50 to 64 miles in circumference and are 7 to 12 miles from the CBD. Five of the eight beltways completely encircle the urban core; partial beltways were built in Louisville, Omaha, and Raleigh. Interchange spacing is relatively uniform (1-1.6 miles) in all cities except Columbus, where the average distance between interchanges is 2.3 miles. San Antonio is unique with frontage roads along much of the perimeter of its beltway, Loop 410.

TABLE 4.1. SUMMARY STATISTICS: CASE STUDY CITIES

	Metropolitan Population 1975 (000s)	Central City Population 1975 (000s)	Percent Change in Central City Population 1960-70	1970-76	HUD City Needs Index (1-Greatest Distress)	Central City Retail Sales Growth[a] Index 1967-72	1978 Size of Central City (Square Miles)
Atlanta	1,790	430	+1.6	-11.9	9	0.44	131
Baltimore	2,150	850	-3.5	-6.0	6	0.33	78
Columbus	1,070	540	+14.6	+1.7	37	0.96	180
Louisville	890	360	-7.4	-7.1	17	0.40	60
Minneapolis/ St. Paul	2,010	660	-5.6	-11.4	28-34	0.22	107
Omaha	570	370	+18.9	+3.6	49	1.04	77
Raleigh	460	130	+30.8	+9.3	NA	1.04	55
San Antonio	980	770	+9.1	+20.6	19	0.91	263

[a] Expressed as a ratio of central city to metropolitan area sales growth.

Source: U.S. Bureau of the Census, U.S. Department of Housing and Urban Development

The oldest beltways are in Baltimore, Louisville, Raleigh, and San Antonio where major segments had been opened to traffic by the early 1960s. Relatively young beltways are found in Columbus and Omaha; beltways in the other cities were substantially complete by 1970.

Traffic volumes show greater variation on the beltways themselves than between cities of comparable size, indicating the distribution of activity within an urban area. For example, average daily traffic on the Baltimore Beltway is highest north of the city where 1978 peak volumes of 113,000 vehicles were recorded. South of Baltimore on the Francis Scott Key Bridge, a recently opened toll facility, volumes drop to 16,000. Table 4.2 provides a compact, statistical description of each case study beltway.

CASE STUDY CITIES: SIMILARITIES AND DIFFERENCES

Building the Beltway

Most local informants indicated that beltways have had an impact on urban development patterns, contributing to the suburbanization of residential, commercial, and industrial activity and to the decline of downtown retailing. Other influences though were far more important determinants of urban form and central city health. Most important of these was the absence of effective transportation planning requirements, tying public facilities planning to transportation and land use planning and development regulation. The authority or willingness of cities to annex land during the 1960s was an important determinant of fiscal and economic conditions in the 1970s. The following sections present the major findings of the case studies.

TABLE 4.2. BELTWAY CHARACTERISTICS IN CASE STUDY CITIES

	Length (Miles)	Number of Interchanges	Average Distance Between Interchanges (Miles)	Miles From CBD	Year of Initial Opening and Substantial Completion	Average Daily Traffic Volumes	Percent of Beltway in Suburbs
Atlanta (I-285)	64	46	1.4	6-11	1962-69	51-120,000 (1978)	80
Baltimore (I-695)	51	46	1.1	7	1955-62 1977- Key Bridge	16-113,000 (1978)	100
Columbus (I-270)	56	24	2.2	6-12	1968-75	20-55,000 (1978)	55
Louisville (I-264)	23	22	1.1	4-7	1949-70	35-97,000 (1979)	40
Minneapolis/St. Paul (I-495, I-694)	54	54	1.0	7-12	1951-70	12-88,000 (1978)	100
Omaha (I-680)	13	8	1.6	5	1965-75	3-39,000 (1978)	0
Raleigh (U.S. 1 and 64)	14	9	1.6	2-4	1961-64, 1977	36-45,000 (1978)	0
San Antonio (I-410)	64	41	1.6	9	1957-66	10-112,000 (1978)	10

Source: Blayney-Dyett from information provided by state highway departments

Route and Corridor Studies. In the case study cities, the beltways usually were located at the fringe of the existing urban areas, five to twelve miles from downtown. Because most beltways were intended to serve as bypass highways—the rationale qualifying them for inclusion in the Interstate Highway System—an alignment through open land was the least costly route to build. In some cities, routes were moved farther out to remain outside urban developments, thereby avoiding disruption and displacement. In Atlanta and Columbus this decision moved the beltway north, while in Minneapolis-St. Paul and San Antonio the beltway was moved out on the east and west side, beyond the alignments of older loop roads which served strip commercial development.

Figure 4.1 illustrates the relationship between beltways and residential development in Atlanta, Columbus, and San Antonio, showing the range of conditions occuring in the case study cities. San Antonio is typical of the beltway located relatively close to the "urban fringe": since the beltway was completed in the early 1960s, scattered residential development has continued on the north side but, for the most part, the beltway delimits the extent of residential development at urban densities (1,000 persons or more per square mile).

Atlanta is typical of a rapidly-growing area where the beltway was located outside the urban area in 1960, but since then residential development has extended well beyond the beltway. Atlanta planners in the 1952 Up Ahead Regional Plan viewed the beltway as an urban form-giving element. By contrast, the Columbus Outer Belt still runs primarily through open land, although residential development and urban densities have extended out to its perimeter on the north side and beyond the Outer Belt on the east side.

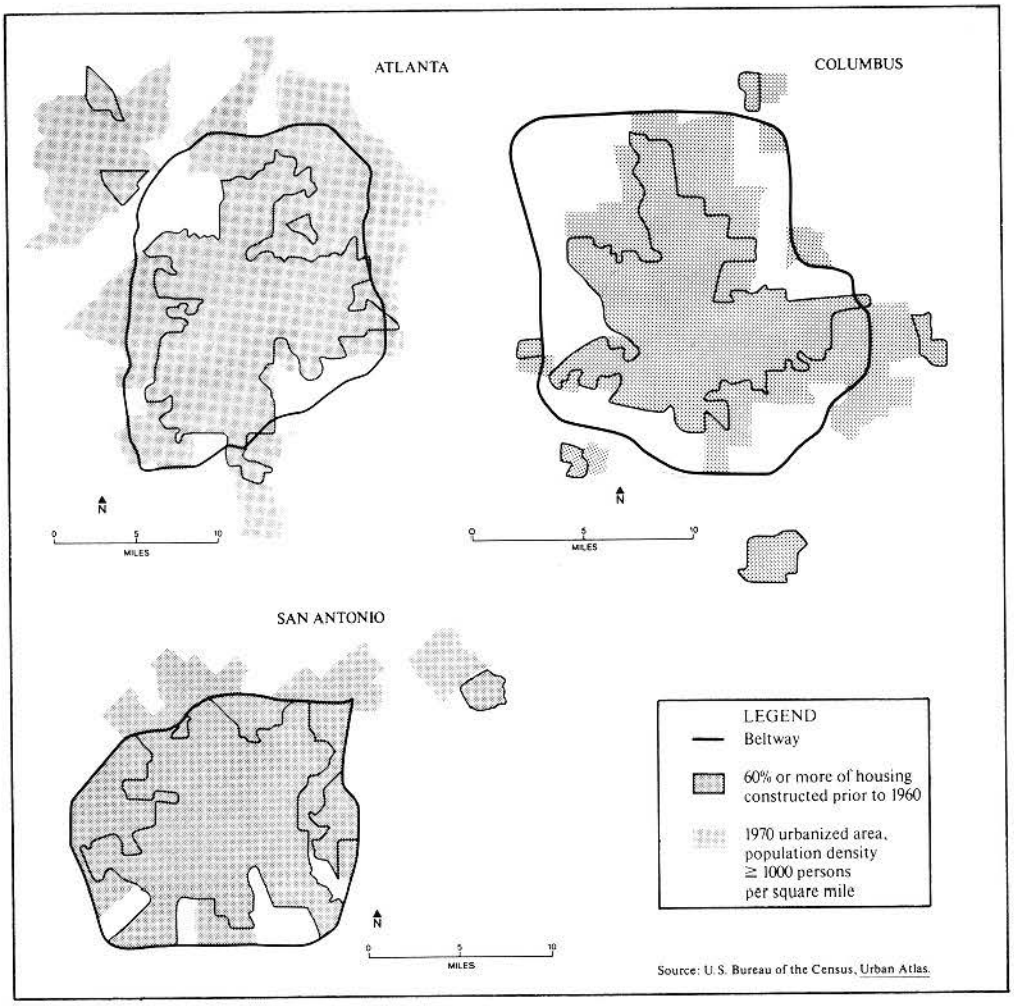

Figure 4.1. BELTWAYS AND RESIDENTIAL DEVELOPMENT

Although the beltway routes in the eight study areas were mapped in the 1940s or earlier, the major planning and design effort occurred after the 1956 Federal-Aid Highway Act shifted the financing burden to the federal government under 90-10 cost sharing arrangements. The Raleigh Beltline, built as a state route, was an exception. For the most part, planning for circumferential or bypass roads undertaken in the 1940s or early 1950s rarely was more than an engineering effort with little coordination between the transportation planners and the land use planners. Some studies addressed route and corridor alternatives; none included a systematic assessment of land use and transportation relationships, consistency with general plans and zoning, or environmental effects. Only in Columbus were recommendations made for coordination of capital improvement programs to serve corridor patterns.

None of the beltway planning studies addressed the relationship between circumferential highways and radial transit service. For example, park-and-ride lots might have been planned as part of a regional shopping center development and preferential access provided for express buses. In Baltimore and Atlanta, planning for rapid transit systems acknowledged the accessibility the beltways provided, but proposed stations near beltway interchanges are not conceived as joint development projects, physically and functionally related to the highway, although access from the beltway, at least in Atlanta, was an important siting criterion.

In San Antonio, VIA Metropolitan Transit initiated an express bus service on Loop 410 in 1977. Although these lines produced only half the revenues of a radial line running downtown, the district is encouraged by ridership increases that exceed system-wide averages. In none of the other communities studied were beltway transit services offered.

Interestingly, both the "3C" transportation planning requirements established in 1962 and the land use planning requirements mandated by Section 701 of the 1954 Housing Act, as amended, had little apparent impact on early beltway planning. By 1956, nearly all the routes had been mapped as part of the Interstate System planning and cost-estimating activities. These never were questioned seriously in subsequent area-wide transportation planning efforts, which focused on system needs and differences between network alternatives - all containing a beltway.

The 701 planning activities were to include a land use element with "implementing procedures necessary for effectively guiding and controlling major decisions as to where growth shall take place within their recipient's boundaries and as a guide for governmental policies and activities, general plans with respect to the pattern and intensity of land use for residential, commercial, industrial and other activities" (P.L. 560). Nearly all early plans devoted minimal attention to beltway corridor land use issues; those that addressed the subject at all were not officially adopted by the governing body of the city or county, so decisions on zoning, rezoning or variance requests invariably were decided without having to meet any "consistency" test.

Interchange Spacing. Interchanges usually were built to connect the beltway with every major radial corridor and with local streets in many communities. This resulted in spacing ranging from less than 0.5 mile between interchanges in developed areas, as in Baltimore, Louisville, and San Antonio, to 2.5 mile intervals in Columbus. In most case study areas interchange spacing averaged 1-1.5 miles. Interchanges rarely were added after the beltway was completed. Only in Minneapolis-St. Paul has a new interchange been proposed to serve a regional shopping center east of St. Paul; in other metropolitan areas, interchanges have been rebuilt to overcome capacity deficiencies when traffic projections understated actual use.

Land Acquisition and Construction. Most state transportation department officials and local planners do not recall much community opposition to beltway proposals; rather, most people supported the concept of an Interstate beltway. As a consequence, right-of-way acquisition proceeded smoothly, a task made easier by the decision to route the beltways through undeveloped land. Displacement caused by the beltways was inconsequential; only in Louisville were some homes acquired, causing displacement of 520 households in the Shawnee Expressway corridor. In Atlanta, Baltimore, Minneapolis, Omaha, and San Antonio community opposition to

inner city freeways halted work on important radial links, but local people rarely opposed construction of circumferential highways which did not appear to disrupt existing communities and neighborhoods.

Location, Capacity, and Use. In the large metropolitan areas where the beltway is located almost completely within the suburbs 6-12 miles from the central business district, average daily traffic exceeds 100,000 vehicles in Atlanta and Baltimore and reaches many thousand vehicles in Minneapolis-St. Paul. The Atlanta Beltway shows the highest use in all quadrants; the lowest traffic is 50,000 vehicles a day. By contrast, in both Minneapolis and St. Paul lightly-travelled sections show volumes in 12-16,000 range—an indication that little development is occuring in these corridors. Truck traffic is typically 7-9 percent of total traffic in all three areas. Through traffic, evidenced by the proportion of vehicles with out-of-state license plates, is 4-5 percent in Atlanta and 8-9 percent in Baltimore; no statistics are available for Minneapolis-St. Paul. In all three of the large metropolitan areas, the beltway is viewed as an essential component of the regional highway network, but only in Minneapolis-St. Paul is there available capacity on heavily travelled links.

In the mid-sized metropolitan areas of Louisville and San Antonio peak traffic volumes are comparable. In Columbus, the highest daily traffic is only 55,000 vehicles. The range of traffic is greatest in San Antonio where volumes on the northside, 112,000 ADT, are ten times greater than volumes on the southside, 10,000 ADT. In Louisville and Columbus, the differences are not as great: 20-55,000 and 35-95,000, respectively. Looking at the beltway in relation to other components of the urban highway network, local planners agree that the beltway is essential to connect and serve urban development in Louisville and San Antonio, but not essential in Columbus because of the low traffic volumes and growth rates that were slower than anticipated. The San Antonio Beltway also connects four military bases, a purpose of the older Loop 13 which the Interstate beltway supplanted.

Beltways in the three mid-size metropolitan communities are quite different in size, location, and interchange spacing. San Antonio's 64-mile beltway has frontage roads along its perimeter and 41 interchanges. It is located almost completely within the city limits, 9 miles from the central business district. Columbus' approximately 56-mile beltway has only 24 interchanges and runs about equally through suburban communities and through the city itself, with distance from the central business district ranging from 6 to 12 miles. In Louisville, about 60 percent of the 23-mile beltway with 23 interchanges is located in the city, and the beltway is relatively closer to downtown than in the other cities (4-7 miles). Louisville and San Antonio are older belts, completed 10-25 years ago, while Columbus is a relatively new belt with some segments opening as recently as five years ago.

In the two small metropolitan areas studied, Omaha and Raleigh, the beltways are 13-15 miles in length and have 8 and 9 interchanges, respectively. Both beltways lie within the city limits, within 2-5 miles of downtown, and heavily travelled segments carry comparable daily traffic (39-45,000 ADT). However, northern segments of the Omaha beltway were completed rather recently (1975), while the northern half of the Raleigh Beltline was open to traffic 16 years ago. The southern half is under construction.

Projections prepared in the 1950s generally underestimated the increase in traffic volumes throughout metropolitan areas by 30-40 percent, but this was not because population growth was understated. Rather, planners did not anticipate the extent of suburban development, fostering an automobile-oriented growth pattern. They also did not foresee the growing workforce participation rate among women, a factor which greatly influence peak hour travel. Urban transportation systems, particularly freeway plans, were designed to accommodate less traffic than they actually had to carry.

Outer Belts. Outer belts were planned in Baltimore, Columbus, Louisville, and San Antonio. In Columbus, an inner belt, just outside the central business district, routes traffic around downtown. The beltway, known as the Outer Belt, was set farther out than originally proposed in order to avoid having to build a second "outer-outer beltway". In Louisville, there are three circumferential highways: the Waterson and Shawnee expressways (I-264), which were the subject of the case study; the Outer Loop, a major arterial without limited access or grade separation; and the Jefferson Freeway, a limited-access, grade separated highway currently under construction. These three highways are spaced three miles apart and are four to twelve miles from downtown. In San Antonio, the Outer Loop, a farm-to-market road proposed to be upgraded to a four-eight lane limited access highway, is located five-six miles north of Interstate 410, the San Antonio beltway. This Loop would only extend halfway around the City.

In Baltimore, two outer beltways and one inner loop were proposed in the early 1960s, but parts were subsequently deleted because, upon further study, transportation planners could find no justification for it. The Baltimore beltway carries through traffic around the City and also serves local trips. The proposed outermost beltway, located 15-20 miles from downtown, could not be justified as a bypass highway because it would significantly increase travel times for most through traffic and not be competitive with the Baltimore beltway even during peak congestion periods.

Importance of Beltways as Transportation Facilities

In nearly all case study areas, the beltways provided a valuable contribution to metropolitan and inter-regional mobility. Particularly in the older eastern and southern case study cities which historically have radial rather than grid street and highway networks, a crosstown system was essential to respond to demand for non-downtown oriented trips. Most beltways were designed to serve as bypass facilities, accommodating through traffic and keeping through traffic out of central areas where they caused congestion. However, in few areas can a four or six-lane freeway be justified for the anticipated flow of through traffic alone. Only Atlanta and Baltimore have substantial amounts of through traffic, for which the beltway provides faster or less congested routes than could radial freeways or highways. With no radial freeways through the city, the Raleigh Beltline does provide an excellent alternative for the limited volume of through traffic, but primarily serves as a high capacity distributor for Raleigh trips.

Over time, the dramatic post-World War II growth of metropolitan areas, the lack of effective planning and a propensity to build as many interchanges as possible attracted extremely high volumes of locally oriented trips to the beltways. As a consequence, many facilities had to be widened many years ahead of anticipated dates in order to accommodate traffic from unanticipated development.

Effects on Land Use Policy and Capital Improvement Programming

In most communities studied, planners recognized the ability of highways to influence land use; however the policies they recommended for adoption in the 1950s and 1960s rarely sought to capitalize on the opportunities for coordinated corridor development and hardly ever addressed the link between outlying development and downtown vitality. The task was to accommodate growth and suburban development by building infrastructure. With a growing awareness of the need to establish urban service areas and utilities' policies for extension, some planners offered beltways as a logical urban limit line; but in most metropolitan areas, continued development beyond this limit prevented the beltways from performing this function.

Typical of this concept is the 1952 regional plan proposal for a beltway around Atlanta:

> The proposed Outer Belt Highway would flank a railroad belt line and with it form the "boundary line" of the metropolitan development area. It would circle the entire area, serving primarily as a fast truck route between the large industrial districts on the rim. Portions of it could be built as each new industrial district is developed, although its full effectiveness as a circumferential would not be felt until the entire loop is completed.[2]

The Atlanta beltway follows this route; but by the time the beltway was completed in the 1960s, suburban development had spread well beyond it in several directions, eliminating the possibility of using it as an urban boundary (see Figure 4.1).

In 1975, urban service area limit lines were established one to five miles beyond the beltway in Baltimore and Minneapolis; in San Antonio a proposal to set an urban service area boundary is contained in a draft Master Plan under review by the Planning Commission at the time this report was written (June 1980). None of these policies presumes that a beltway itself should represent the edge of urban development—a concept that does not make much sense because the accessibility a beltway provides enhances the development potential of buildable land.

In Omaha, city planners produced an Urban Development Policy in 1977, intended to arrest spreading residential development and to bolster downtown. The beltway is employed as the boundary between the "in-city" area and the "zone of present development", but otherwise no actual or desirable relationship between the beltway and urban land use is discussed or promoted. In effect, this policy continues to encourage suburban development without offering substantial incentives to revive the city's core area. Omaha's city limits might have been drawn somewhat tighter in the absence of the beltway. Once the beltway was built, the city annexed a narrow band of land on either side of the belt along several segments of the facility to extend the city's area of zoning control. This maneuver might not have been accomplished in so large a way had the beltway not existed.

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2 Metropolitan Planning Commission, Up Ahead (Atlanta: February 1952), p. 65.

In nearly all the local land use plans prepared in the 1960s (with the exception of those done in the Twin Cities metropolitan area and in Raleigh in the late sixties), beltway interchanges, especially those which did not serve a major radial freeway, rarely were designated as the focal point for intensive commercial development, a regional shopping center or, where multiple use concepts were in vogue, a town or sector center. Since few plans actually were adopted by local governments during this period, such development sometimes occurred contrary to the planners' expectations; examples of this were found in Baltimore, Louisville and San Antonio. At one time, Baltimore County planners sought to limit the intensity of development in highway interchange quadrants, but this proposal never was adopted and implemented.

The Twin Cities Metropolitan Council, created by the Minnesota Legislature in 1967, used the beltway as an important transportation component of its regional plan, linking subregional centers with each other and with radial corridors. Three of the eight subregional centers are within one mile of the beltway, as illustrated in Figure 4.2. However, the planners did not give any specific attention to beltway corridor land use issues until recently as the pros and cons of the Woodbury Center were debated. The Metropolitan Council working with the State Department of Transportation, recently formulated and implemented innovative policies for interchanges intended to limit highway-related development opportunities that would be inconsistent with local and regional land use policy.[3]

Where local planners recognized that certain key interchanges were likely to attract intensive development, this anticipation was not sufficient for the highway department planners to build high capacity interchanges. These were generally built to serve existing high volume routes and freeway to freeway interchanges. While highway departments did not have to build more substantial interchanges everywhere in anticipation of land use changes, sufficient right of way could have been acquired and designs adopted which did not preclude later improvements at reasonable cost. Examples of such interchange capacity problems caused by unanticipated development were found in Atlanta, Baltimore, and Louisville.

Only in the Baltimore County planning documents was there any concern about the effects of new commercial development on existing commercial areas—an issue only now addressed by the President's Community Conservation Guidance.[4] This is illustrated by the quotation on the following page from the 1975 Comprehensive Plan, which was adopted by the Planning Commission but not the County Council, and, consequently, never was implemented.

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3 Metropolitan Council, Metropolitan Highway Interchanges (St. Paul, July 1979).

4 Executive Order dated November 26, 1979.

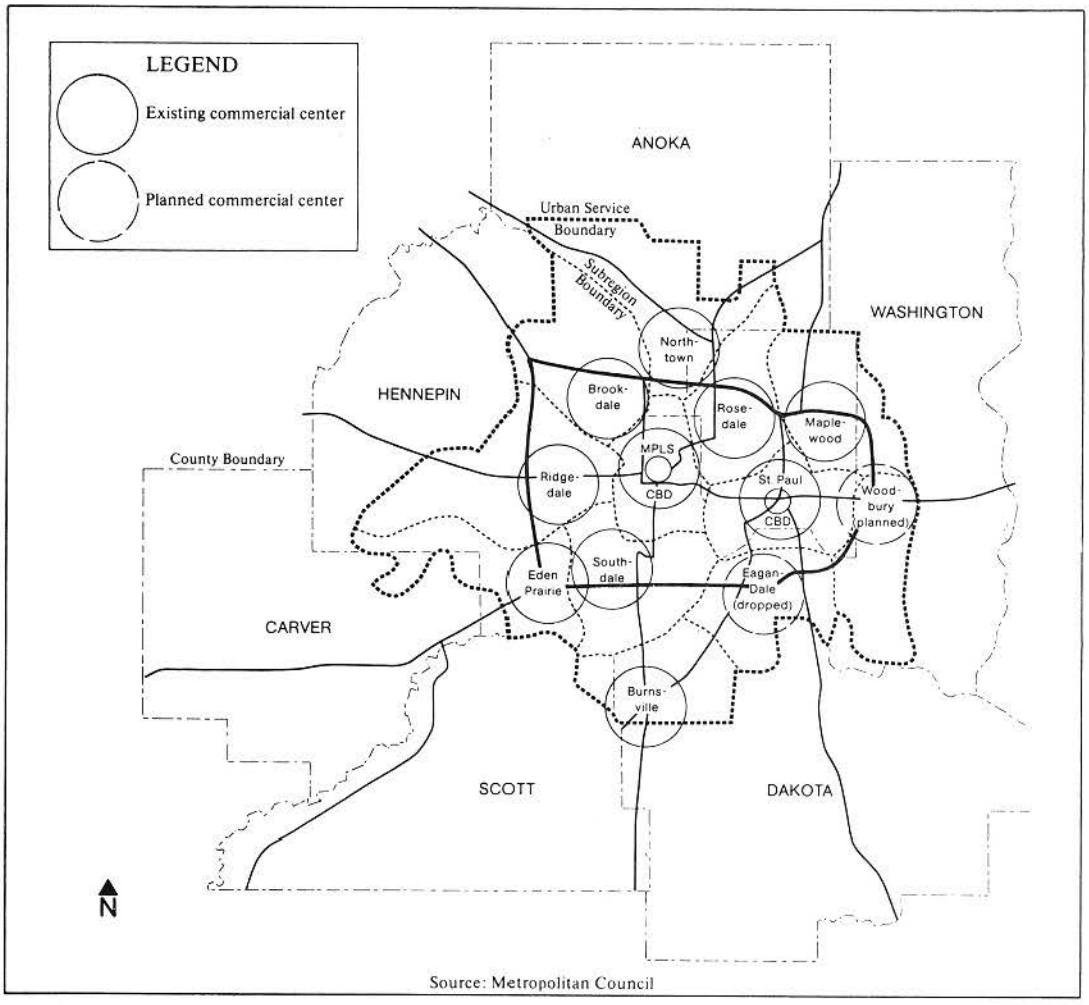

Figure 4.2. MINNEAPOLIS/ST. PAUL SUBREGIONAL CENTERS

The County should require commercial facilities to be located, as far as possible, so as to encourage pedestrian circulation and promote the neighborhood community and town heirarchy of streets and roads. New commercial centers at more advantageous locations in relation to new highways and mass transit facilities than older centers should not be constructed if they will take over the functions and thereby destroy the economic viability of the established centers. Such a process has occurred in Essex with the building of Middlesex, Eastpoint and Golden Ring Mall. It could also happen elsewhere in the County and result in failing businesses and rows of abandoned stores. New commercial zoning, therefore, should reflect only well-documented and justified additional needs and should be provided only in the locations indicated on the plan.[5]

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5 Baltimore County Office of Planning and Zoning, Baltimore County Comprehensive Plan, 1975, (Towson, October 1975), p. 34.

By neglecting these interrelationships and adopting a permissive attitude toward corridor development, Baltimore County indirectly affected the City of Baltimore's retail base. However, officials in the city historically did not view retailing as the cornerstone of its revitalization efforts, emphasizing instead the need for more office, industrial, and residential development downtown and a new convention center.

Columbus represents the best case of integrating the beltway into local land use planning. The limited number of interchanges offered fewer opportunities for beltway-related land use within interchange quadrants. The principal components of land use policy in Columbus were capital improvement programming and annexation to the city. Following creation of a regional water and sewer system in 1954, the City of Columbus adopted a policy in 1957 that service would be extended only to incorporated areas. To effect this policy, the city has expanded substantially, from 42 square miles in 1954 to 180 square miles in 1980. In 1970, a review of city annexation policy recommended that first and second priority areas for annexation should include land "substantially affected by the outer belt."[6] Although historic growth was outward along the main arterials, the city's current 1985 land use plan favors a less radially-oriented form of development with ultimate urban boundaries extending beyond the outer belt in several directions.

Effects on Development Decisions

In Atlanta, Louisville, Raleigh, and San Antonio, the beltways appear to have influenced suburban development decisions, drawing high density residential, commercial, and industrial activities into the corridors they serve, and reinforcing historic development trends. However, they cannot create a market for developable land where none exists, as illustrated by the relatively undeveloped land along segments of the beltway in almost all case study areas. Differences between case study areas are more a function of the location of the beltway and the characteristics of the local real estate market than the size or economic vitality of the metropolitan area, as the following overview of effects in each area demonstrates.

Among the large metropolitan areas, the beltway in Atlanta had the greatest effects on real estate investment decisions. Developers of multi-family housing, suburban office parks and towers, and shopping centers have all sought sites visible and/or accessible from I-285. Analysis of development patterns over time suggest there was a "one-time shift" to the corridor, followed by a reversion to prevailing trends—an effect most evident in the office sector. Within the northern and northeastern neighborhoods, the focus of upper income residential development, most interchange quadrants and frontage areas are "built out"; 60-80 percent of the land has been

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6 Arthur D. Little, Inc., Annexation Issues and Recommendations (Columbus: Columbus Department of Development, 1970), p. 4.

developed for intensive commercial or residential use. Land prices on remaining sites are the highest in suburban Atlanta, up to $120,000 per acre, slowing the rate of further development. However, in other, less prestigious sections of the beltway corridor, interchange development is slower and less intense. Between interchanges, there is a considerable amount of land vacant and for sale with visibility but not accessibility from I-285. According to informants in the real estate industry, accessibility from I-285 can affect land values within a half mile, and premiums range from 20 to 100 percent depending on location and zoning.

In Baltimore, the beltway attracted developers to nearby sites in the 1960s, but the corridor itself has not captured an increasing share of construction since 1964—a clear indication that it has not affected overall demand by improving access to specific sites. Vacant developable land on the beltway commands a $10-$20,000 per acre premium over in-town sites or sites in industrial and office parks. However, the beltway's influence appears to be waning on all segments of the development industry, except for multi-family housing, and retail sales at beltway centers have not shown above average growth since 1972. Further, land use statistics show that the Baltimore beltway has not focused development; far greater activity is occuring beyond the beltway than in the beltway corridor, suggesting that the facility has become a less important locational factor in decided contrast to the Atlanta experience.

In the Twin Cities, most of the belt has not had much impact on development decisions. In the main, it runs through open land, vacant or in agricultural use, and suburban neighborhoods of single family housing units. Notable exceptions are the intensely developed strip through Bloomington and Richfield near the airport and the large corporate facilities of Land O'Lakes, Control Data, and Prudential. The belt has not pulled residences, offices, retail stores, or industrial space outward. Each of these uses established itself in the suburban municipalities, drawn by attractions other than the belt. The Twin Cities belt has influenced the distribution among suburban locations of office and retail space; neither industries nor residences, multi-family or single-family, are oriented to the beltway.

Turning to the mid-sized metropolitan areas, the effects are similar, i.e., existing development trends were reinforced. In Columbus, the Outer Belt provided a focus for some suburban multi-family, office, and industrial park development. However, much land on the western and southern portions of the belt remains vacant, partially because the Outer Belt was recently completed, but also because the regional growth rate in recent years has been well below the rate anticipated when the Outerbelt was planned. Land prices in suburban Columbus and nearby communities fall in the $40-70,000 per acre range, commercial or industrial land with freeway accessibility and visibility commanding the higher prices. Land along the radial freeways costs somewhat more than along the Outerbelt, perhaps because less land is available near the radials.

In Louisville, where the Watterson Expressway was built through undeveloped areas, it had a significant, one-time effect on locational decisions for office space, retail centers, and multi-family housing. On the other hand, where it was built through existing older neighborhoods, it had little effect on adjacent land use; no private redevelopment or intensification is apparent. Commercially zoned sites with beltway visibility and accessibility command a premium price in relation to sites lacking these characteristics.

In San Antonio, Loop 410 on the north side had some effect on the distribution of new offices, retail space and industrial parks. Today, the corridor is intensively developed, and space rents at rates comparable to downtown. However, a clear impact on housing development patterns and institutional uses is not apparent. On the south side, land remains largely in agricultural use, and the city has received no rezoning requests, nor are any development proposals known to be under preparation. Downtown development decisions appear largely unrelated to Loop 410, having been influenced by market factors and public incentives, mainly assistance in land assembly. In the late 1960s and early 1970s, a one-time shift in construction activity out to the North Loop 410 corridor, possibly influenced by the continuing uncertainty about the McAllister Freeway, had some detrimental effect on downtown.

In the small metropolitan areas, greater effects are evident in Raleigh than in Omaha. In Raleigh, a significant amount of development occurred close to beltline interchanges.

> In total, there were six service stations, two chain motels, 20 new industries, one moderate size and three large shopping centers, 45 institutional or office developments, and 11 apartment complexes having over 2,100 units—a total of 77 developments, excluding the residential units or an average of 10 per interchange. These types of developments are continuing after 1972, making use of all of the available land.[1]

Today, few sites remain in interchange quadrants for further retail development, although intensification of existing development is possible. Interestingly, all three major retail centers in Raleigh have decked parking to make better use of small, expensive sites. Potential sites do remain for office space and industrial development along the beltline; however, premiums reflecting accessibility may be slowing sales. As in other case study areas, development and land price effects are strongest in prestigious areas with strong markets; prices and activity along the uncompleted portions in lower income and black neighbornoods have been little affected by the promise of beltline accessibility.

By contrast, in Omaha the beltway runs through open, undeveloped land on Omaha's northern and northwestern perimeter for most of its length. This area does not invite construction, lacking utilities and other infrastructure. The single segment of the belt which has attracted development is the link between I-80 and Dodge Street. Office and retail establishments are drawn to this location by the accessibility to the middle- and upper-income suburbs which located to the south for reasons unrelated to the presence of the beltway. Industrial firms have not shifted to beltway sites from their present situation along I-80.

Such impacts can best be understood by looking at a beltway's potential ability to influence development decisions for each type of land use, starting with housing and then examining influences on location decisions for retail and office space and industrial parks.

Housing. In housing development, beltways have had the greatest influence on the location of large garden apartment complexes, where the visibility a freeway location provides has helped rentals. This has increased the range of housing opportunities in suburban communities. If beltways had not been built, such higher density, lower cost housing probably would have been built closer to the core or in arterial corridors. Initially, beltways may have contributed to suburban development by providing improved access between radial corridors. However, over time they may promote compact growth and contribute to the feasibility of infill development, by concentrating high density housing within the corridors they serve. This effect was not apparent in all cases; scattered outlying development continues in some metropolitan areas, particularly where land use planning and development regulations are weak.

In Baltimore, for example, the beltway corridor's share of acreage used for moderate-high density housing in the region increased from 18 to 20 percent between 1964 and 1976, while the percentage of single family acreage in the corridor declined from 42 to 36 percent over the same period. Between 1964 and 1973, one-quarter of all moderate-high density development occurred in the beltway corridor. Subdivision activity from 1970 to 1973 confirmed this attraction; the beltway corridor accommodated about the same number of residential dwellings on one-third of the total acreage subdivided in the balance of Baltimore County. In Raleigh, one-half of all multi-family housing built between 1961 and 1972 is within 7,000 feet of a beltway interchange and 39 percent within 4,000 feet. Similar concentrations of apartment development are evident in Atlanta, Columbus, Louisville, and San Antonio.

Only in Minneapolis-St. Paul and Omaha did the beltways not attract substantial numbers of apartment units. This is because the beltway was beyond the area where higher density rental housing would normally locate. Raleigh apartments were visible through the heavily wooded corridor near interchanges, but advertising signs were not visible, unlike the other case study areas where major beltway-oriented apartment complexes carried advertising that could be seen by beltway drivers.

In none of the case study areas was a concerted effort made to site federally subsidized housing in the beltway corridor to increase low and moderate housing opportunities for those working in major suburban employment centers. Neither regional housing opportunities plans nor local housing assistance plans typically view the accessibility provided by a major highway, such as a beltway, as an important factor in evaluating potential sites or the distribution of need. This becomes important when highways affect the distribution of employment opportunities, but not housing opportunities for all segments of the community.

Effects on single family housing are less clear. A beltway may open up land closer to the central business district that was relatively inaccessible because of its location between radial corridors, thus resulting in a more compact or infill development pattern. However, as a secondary effect, the movement of employment centers to the beltway may have encouraged people to select residential areas even farther out from the city, thus promoting a greater amount of scattered development.

7 Khasnabis, S. and W.F. Babcock, op. cit., p. 9.

Other, more important influences on residential development patterns include:

1. **Earlier construction of radial limited access highways.** Radial freeways improved access between downtown and suburban communities and contributed to residential dispersement as developers capitalized on the supply of inexpensive land brought within commuting range. Where downtown Interstate highway segments were not completed in the 1960s or even 1970s, the beltways' impact on development patterns were greater than where good radial access to the core area was assured before the beltway was constructed.

2. **Annexation policies.** Where annexation of developable land was pursued aggressively without land use planning or capital improvement programs, scattered suburban development that bore little relation to planned highway systems often resulted.

3. **Availability of water and sewer service.** Extension policies that did not discourage leap frog development were another important cause of scattered suburbanization in many metropolitan areas.

4. **Changing central city racial mix and school busing orders.** Many key informants felt this was a strong impetus to the rate of suburbanization, particularly in the early to mid-1970s. This was a factor in both northern and southern cities. No empirical substantiation is available.

5. **Federal Housing Administration lending policies.** Well into the 1960s, the Federal Housing Administration did not insure loans for homes in the central cities of many metropolitan areas; and thus these programs facilitated the purchase of suburban housing. Since FHA loans often have smaller down payments than conventional loans, many young householders purchasing a first home with little equity were "led" into the suburbs where costs of housing were lower.

Retail and Office Space. Beltways have influenced the distribution of office space and the location and possibly the success of regional shopping centers, but this latter benefit is waning as new regional centers are built farther out. In Baltimore, 5,000,000 square feet of space is proposed to be built two to five miles beyond the belt; in San Antonio, a major regional mall is planned on the outer loop, six miles north of the beltway; and in Louisville, seven shopping centers containing 1.9 million square feet of space are proposed outside the beltway.

From a retail marketing perspective, the interchange of a suburban beltway and major radial probably is the second most accessible point in a metropolitan area (after the CBD). In many cases, it may offer developers better accessibility to upper income markets than a downtown location because of traffic congestion on radial freeways and arterial streets. It also offers developers substantially lower land development costs. However, beltways do not attract growth where growth forces did not exist previously. Rather, they attract and reinforce prevailing growth and development trends. Table 4.3 summarizes the distribution of major retail centers in case study areas by size and location. Overall, 23.4 million square feet of space, 50 percent of the space in regional shopping centers, is within beltway corridors.

TABLE 4.3. DISTRIBUTION OF MAJOR RETAIL CENTERS BY SIZE AND LOCATION IN CASE STUDY AREAS, 1980
(Square Feet of Space, 000s Omitted)

	Beltway				Non-Beltway				
	400,000-699,000	700,000-999,000	One Million+	Subtotal	400,000-699,000	700,00-999,000	One Million+	Subtotal	Total
Atlanta									
Number of centers	—	3	1	4	5	2	2	9	13
Total square feet	—	2,550	1,415	3,965	2,037	1,550	2,240	5,827	9,792
Percent of total	—	26	14	40	21	16	23	60	100
Baltimore									
Number of centers	2	1	1	4	5	1	—[a]	6	10
Total square feet	1,196	850	1,110	3,156	2,896	736	—	3,632	6,788
Percent of total	18	12	16	46	43	11	—	54	100
Columbus									
Number of centers	1	1	1	3	3	1	—	4	7
Total square feet	431	959	1,092	2,482	1,627	800	—	2,427	4,908
Percent of total	9	20	22	51	33	16	—	49	100
Louisville									
Number of centers	4	1	—	5	3	1	—	4	9
Total square feet	2,210	750	—	2,960	1,355	993	—	2,348	5,308
Percent of total	42	14	—	56	26	18	—	44	100
Minneapolis-St. Paul									
Number of centers	1	1	2	4	2	2	3	7	11
Total square feet	459	939	2,044	3,442	959	1,895	3,491	6,345	9,787
Percent of total	5	10	21	35	10	19	36	65	100
Omaha									
Number of centers	0	0	1	1	2	0	0	2	3
Total square feet	—	—	1,165	1,165	1,040	—	—	1,040	2,205
Percent of total	—	—	53	53	47	—	—	47	100
Raleigh									
Number of centers	1	—	1	2	1	—	—	1	3
Total square feet	600	—	1,000	1,600	600	—	—	600	2,200
Percent of total	27	—	46	73	27	—	—	27	100
San Antonio									
Number of centers	—	3	2	5	z	—	—	2	7
Total square feet	—	2,250	2,400	4,650	960	—	—	960	5,610
Percent of total	—	40	43	83	17	—	—	17	100

a. White Marsh, a 1 million square foot center, is under construction and scheduled to be open in the fall of 1981.

SOURCE: Blayney-Dyett, from information provided by city planning departments and the National Research Bureau, Inc., Directory of Shopping Centers, 1978.

This "capture rate" is not unreasonable when comparing development opportunities along a beltway to those along radial freeways within the urban area. Excluding radial freeway mileage through the core areas (where regional shopping centers are unlikely to be built) and beltway or radial freeway mileage in parks or over water, developers could look for sites along about 300 miles of radial freeways or 315 miles of beltways in the case study areas taken together. Given this split, it is not surprising that 50 percent of the shopping center space is on the beltways. Differences among the case study areas reflect local influences on development trends, not any unique attribute of the beltway. Estimates of developable beltway mileage and developable radial mileage by case study area are summarized in Table 4.4.

TABLE 4.4. ESTIMATED MILEAGE OF URBAN RADIAL FREEWAYS AND BELTWAYS ADJACENT TO LAND WITH DEVELOPMENT POTENTIAL

	Developable Mileage		Beltway Mileage as a Percent of Total Developable Mileage
	Radial Freeways	Beltways	
Atlanta	58-64	61	50-60
Baltimore	30-48	37	44-55
Columbus	25-40	56	58-69
Louisville	32	13	29
Minneapolis/St. Paul	30-48	54	53-64
Omaha	10-15	18	55-64
Raleigh	-0-	12	100
San Antonio	32-52	64	55-66
	217-299	315	

Source: Blayney-Dyett

Suburbanization of retail and office space was a post-World War II phenomenon in metropolitan areas. Beltways offered access to a larger market area and thus may have encouraged development of large, outlying shopping centers earlier than would have a transportation system which relied mainly on radial highways and expressways. Developers may seek to pre-empt competition by establishing a strong early presence on a prime site even though the initial market may not justify construction of a "super regional" center. This did not occur in very many case study areas. Figure 4.3, showing the evolution of the beltways and timing of construction of major retail centers, clearly indicates the weak correlation between completion of a beltway segment and opening of a regional mall.

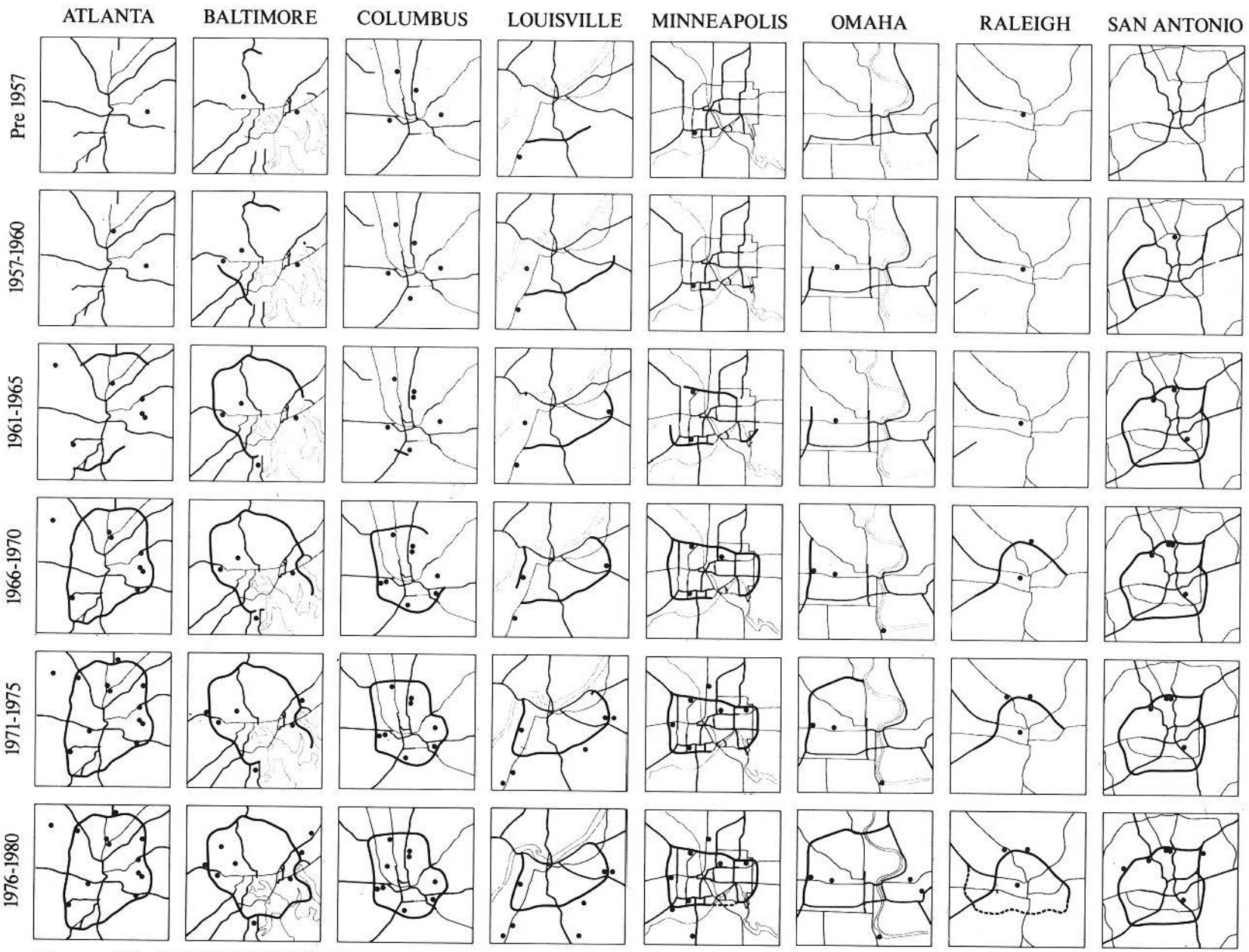

Figure 4.3. EVOLUTION OF THE BELTWAYS

Federal and state agencies also built or leased space at outlying suburban locations with highway accessibility. In Baltimore, for example, the Social Security Administration National Headquarters is located on the beltway at the I-69/I-70 interchange. However, recent federal initiatives to encourage agencies to remain at downtown locations has stemmed the exodus in many metropolitan areas.[8]

Some office uses on the beltway represent transfers of activity from downtown; but, based on evidence obtained in Atlanta, Louisville, and Raleigh, probably no more than 20-40 percent of beltway office activity falls into this category. In many cases, offices were built to accommodate new activity that never would have considered a CBD location. In finance, insurance, and real estate, many businesses prefer a suburban location to be close to customers and to avoid long commutes. In these instances, the beltway allowed, possibly encouraged, development of suburban activity centers. In Atlanta, Baltimore, Louisville, and San Antonio, for example, construction statistics reveal a "one time" spurt of beltway-oriented commercial development, followed by a shift back to the dominant pattern established prior to the opening of the beltway (or an improvement to Interstate highway standards).

More specifically, office space built in the Atlanta beltway corridor was 52 percent of the regional total in the 1970-74 period and only 16 percent in the 1975-79 period. This rapid shift of new construction to the beltway occurred for several reasons: access to the residential neighborhoods of corporate executives; the "higher qualifications" and lower wages demanded by the clerical labor pool in the suburban areas; free parking; shorter work trips and avoidance of congestion travelling downtown; and fear of crime in the city. In the late 1960s and early 1970s, when much of the office space built downtown was planned, renewed interest in CBD probably was due to a combination of factors: recent completion of luxury hotels and commitments to build more; plans for a major convention center and apparel mart; and construction of the MARTA system, which would improve access to the urban core.

Trends in Louisville are similar; the proportion of the new office space built within one mile of the beltway declined from 53 percent between 1960 and 1964 after the beltway was completed to 30 percent in 1965-69, 25 percent in 1970-74, and 7 percent in 1975-79.

This phenomenon also is evident in the retail sales trends; in most areas beltway centers have not sustained above-average growth rates from 1967-72 to 1972-77 as their "competitive edge" dissipates somewhat with continued suburbanization (see Table 4.5).

Failure to maintain the commercial viability of a CBD cannot be attributed to a beltway. In most cities, the core area retail sales "capture" rate began to decline in the 1950s, well before beltways were completed. This is illustrated in Table 4.6, which compares retail sales trends in the eight case study areas from 1954 to 1977. Strong support for downtown from community leaders and the business community, coupled with strong land use and transportation planning and economic development programs, have maintained viable downtowns in some areas, namely Atlanta, Louisville, Minneapolis, and San Antonio (see Table 4.6). In those communities where

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8 Executive Order 12072, Federal Space Management, August 16, 1978.

mayors, chambers of commerce, and active citizens groups were concerned about downtown and made commitments of time and resources to facilitate development, such areas have prospered despite the attraction of sites along the beltway or in outlying suburban communities.

TABLE 4.5. RETAIL SALES TRENDS AT MAJOR RETAIL CENTERS IN CASE STUDY AREAS, 1967-77

	Average Retail Sales (Millions of Dollars)			Percent Change	
	1967	1972	1977	1967-72	1972-77
Beltway Centers	$318	$1,175	$2,385	269	103
Non-Beltway Centers	$683	$1,213	$2,050	78	69

Source: U.S. Bureau of the Census, Census of Retail Trade.

Downtown department stores owned by local families with strong civic ties were more likely to remain open than stores run by national chains. With strong management, many of these stores remained quite successful even in the face of growing competition from suburban malls. In Atlanta, the Rich family, which owned one of the two largest downtown department stores, refused to open suburban stores until the metropolitan area reached one million in population, radial expressways had been built improving access to downtown, a 1,250 space parking garage had been constructed near the downtown store, and a major store remodeling was finished. These conditions ensured the continued financial success of their downtown operation.[9]

In the Twin Cities, the Dayton family made a similar commitment to both downtown Minneapolis and St. Paul, while pursuing development of the "Dales" as major subregional centers. In Baltimore, Omaha, and San Antonio, the remaining downtown department stores are locally owned. However, in Omaha and, to a lesser extent, in Baltimore, interest in maintaining a strong retail core has not been strong.

Downtown retailing can survive by catering to specialty markets, office workers, tourists and conventioneers, inner city residents, or some combination of these. A prerequisite often is an office employment base of sufficient "critical mass" which can support boutiques and restaurants as well as department stores. Larger cities serving as administrative and governmental centers have greater opportunities to retain retailing than smaller cities which have limited downtown employment and/or entertainment activities. In this context, beltways' impacts on the location of office space within a metropolitan region is especially disturbing because it represents a drain on the mainstay of many downtowns, the focal point of major revitalization programs. With sound planning, even the potential adverse effects of a one-time shift might be avoided.

9 Hartshorn, T.A., et al., Atlanta - Metropolis in Georgia (Cambridge: Ballinger Publishing Co., 1976), p. 28.

TABLE 4.6. RETAIL SALES TRENDS IN CASE STUDY AREAS, 1954-77

	Annual Average Percent Change			Central Business District Sales (Millions of Dollars)		CBD as a Percent of SMSA Sales, 1977
	Metropolitan Area	Central City	Central Business District	1972	1977	
Atlanta	9.1	4.4	0.1	320	271	4
Baltimore	6.6	2.4	-0.8	208	194	3
Columbus	7.7	5.7	0.2	231	207	5
Louisville	6.6	3.1	0.9	235	271	9
Minneapolis-			1.7 -MN	285 -MN	325 -MN	
St. Paul	7.9	3.0	-0.9 -SP	105 -SP	91 -SP	6
Omaha	7.0	6.3	-3.0	82	69	3.0
Raleigh	a	10.1b	-4.9b	68	46	a
San Antonio	7.8	7.2	1.2	176	231	7.5
Average	7.5	5.3	-0.6			

a. SMSA redefined, making time series comparisons misleading.

b. 1967-1977 only.

Source: U.S. Bureau of the Census, Census of Retail Trade.

Industrial Development. Suburbanization of industrial activity spurred by land availability and low cost, highway access and visibility, and changes in technology of production and distribution, as well as by inner-city renewal activities, has occurred in nearly every metropolitan area. While highways have been important, rail access, availability of public services, proximity to a skilled labor force, easy parking, room for expansion, the attraction of well-planned and landscaped industrial parks, tax rate differentials, and tax-exempt financing programs also were key incentives for such a pattern of development.

In Atlanta, Columbus, Louisville, and San Antonio, warehousing and non-rail oriented distribution centers have been attracted to areas near beltways, both by accessibility and the effect beltways have had in increasing the supply of land at reasonable cost in industrial parks along Interstate highways. Further, in Columbus, 80 percent of the industrial acreage is within one mile of the Outerbelt; in Raleigh, 50 percent of new industrial development, measured by building permit value, is within 4,000 feet of beltline interchanges; while in San Antonio, 30 percent of the industrial park acreage is in the Loop 410 corridor. Figure 4.4 on page 109 illustrates the movement

of 33 industrial firms in Columbus between 1970 and 1975. Of the total surveyed, 21 moved from a location elsewhere in the Columbus region, and 12 came from other metropolitan areas. Freeway access was valued by all.[10]

In other study areas, the beltway corridors have not been highly favored, although recent activity suggests renewed interest in such locations. Sites on radial freeways generally are somewhat higher priced and usually benefit from rail service. In Omaha, for example, only 2 percent of the industrial park acreage is within one-half mile of the beltway, while in Baltimore, the beltway corridor contains only 15 percent of the industrial park acreage. However, the Baltimore Beltway does provide access to the port and major marine terminals.

While studies indicate that many firms use trucks rather than rail for most of their goods movement, developers favor rail-served sites for added accessibility. Cities also favor rail-served areas for industry because there are few other uses truly compatible with rail lines.

REGIONAL CONSEQUENCES

Economic and Fiscal Effects

Where beltways are located wholly or partially within central cities, the fiscal impacts are not great because any shifts in development and retail activity attributed wholly or partially to the beltway remain within the taxing jurisdiction of the city. Where a beltway is located mainly in suburban communities, the effects on the central city tax base are adverse. Tax base sharing, such as that implemented in Minneapolis-St. Paul in 1975, may mitigate the potential inequities resulting from such a shift in development and reduce competition between jurisdictions for "ratables," allowing somewhat more rational land use planning.

In growth areas with strong economies, many informants believe that beltways enhance the competitive advantage of a metropolitan area and are essential components of an urban highway system. As such, they have a positive effect on the metropolitan economy which, many contend, overshadows the adverse effects on the central city, particularly downtown. In contrast, informants in stable or economically distressed communities suggest instead that the beltway's economic impact, on balance, was negative mainly because of its effect on the central business district. Nevertheless, in both instances, the net impact is not large.

Socio-Economic Effects

To the extent that beltways facilitate suburbanization, they contribute to continued segregation by race and class. They do little to enhance employment and housing opportunities for inner-city minority residents. In Atlanta, Minneapolis, and Omaha, informants contend that construction of the Interstate system created more rigid boundaries between different racial communities, but in others the effects were judged less pronounced.

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10 Thomas Maraffa, Industrial Location and Linkage in Columbus Industrial Parks (Columbus: Ohio State University Department of Geography, 1975), p. 20.

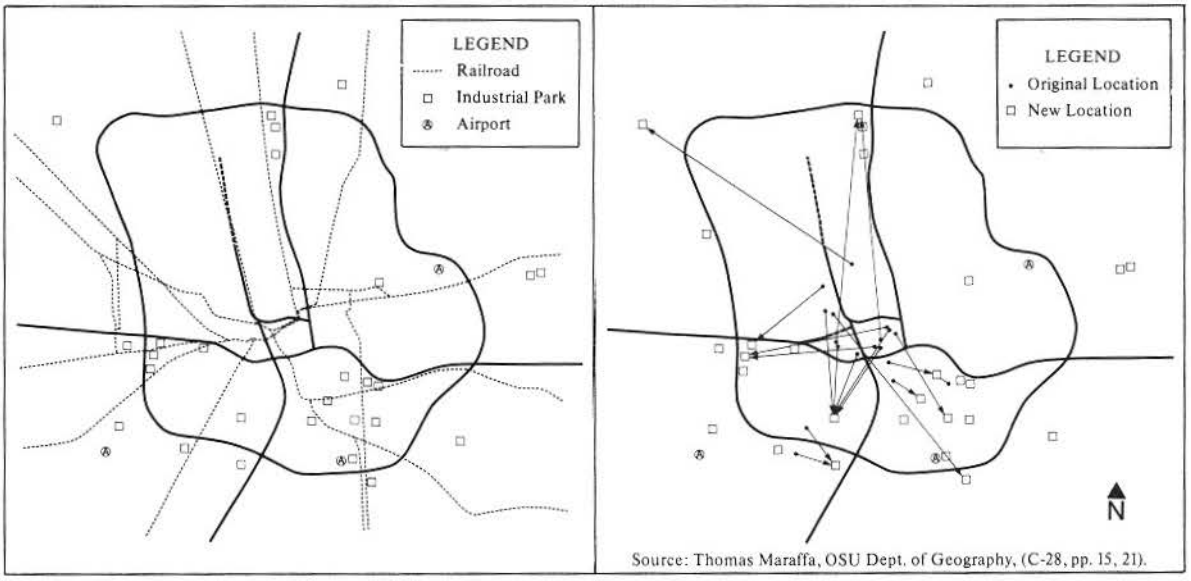

Figure 4.4. MIGRATION OF INDUSTRIAL FIRMS IN COLUMBUS, 1970-1975

Upper income suburban residents have gained the most from beltway development. Development oriented to belts has clustered near higher income white neighborhoods, as in North San Antonio, North Atlanta, Southwest Omaha, and North Raleigh. Beltways were usually built to serve such neighborhoods first, and development of the belts through lower income and minority neighborhoods (south and southwest Atlanta, southside of San Antonio, and southwest Louisville) have had little land use effects and have not stimulated neighborhood improvement. However, in San Antonio, at least, choice of workplace and residence does not appear to have been markedly influenced by the beltway, as illustrated by the diagrams in Figure 4.4 showing 1974-75 residence location for those working in the north beltway corridor and working downtown. However, averages for those two groups is not equal: 4.9 miles for CBD workers versus 5.6 miles for beltway workers—a 14 percent difference.

Central city residents gain little from belts, as reverse commuting is not a major factor in most communities and there is little congestion in reverse commute direction in any case.

Commuting time differences by race probably reflect restrictions in choice of neighborhood, income differences, and mode differences (i.e. greater dependence on slower transit for lower income blacks). All freeway improvements (whether they be radial or belt type freeways) will benefit higher income residents primarily and more suburban residents. Only improved inner city transit service will contribute to mobility of inner city rather than suburban residents.

Similar inequities are evident in travel statistics that show black commuters spending more time to commute shorter distances, suggesting that the urban highway system more adequately meets white commuters' needs. The degree to which the beltway contributes to this difference could not be gauged with any certainty.

Environmental Effects

Environmental considerations rarely were important in initial corridor and route alignment decisions. By virtue of their location, beltways have contributed to conversion of agricultural land to urban use, indirectly fostered development in sensitive areas such as an aquifer recharge area where development now is subject to strict controls, increased suburban residents' exposure to highway noise, and promoted further reliance on the automobile with adverse effects on air quality and energy consumption. Only two state highway departments implemented a noise buffer program; informants in other states thought highway noise to be incidental.

Surveys of travel patterns suggested that beltways have marginally increased vehicle miles traveled and, to a lesser extent, trip times. However, energy consumption may not have been appreciably different than if the beltway had not been built, and may even have been lower, because travel on highways is more energy efficient than travel on city streets. Energy savings deriving from fuel-efficient driving speeds also are attainable by any freeway alternative to a belt route, including a strengthened radial network. Further, as an inducement to development of a major regional center, the beltway may promote one-stop shopping which clearly is preferable to shopping a commercial strip. On the other hand, beltways encourage an automobile-oriented development pattern that is not easily and efficiently served by transit.

There is no quantitative and consistent pattern of beltways on regional air and water quality, but the effects do not seem large in comparison with other factors. In terms of energy consumption, effects are not large, and as is pointed out, possible increased mileage may be offset by improved operating characteristics resulting from higher speeds and less congestion. A polynucleated city has the potential to be the most energy efficient according to some analyses, and the long term effects of beltways on some cities may push them in this direction (Atlanta, Louisville, Minneapolis-St. Paul, and Raleigh are the best examples).

COMPLEMENTARY MEASURES

The construction of a beltway in a region will affect local urban development patterns in a manner determined by local conditions, such as the rate of urban growth and the liberality of land use controls, and the particular attributes of the beltway, such as capacity, level of access, and interchange spacing. The beltway's influences can be mitigated or enhanced to conform better to local planning objectives through the use of complementary measures. The potential arsenal of such measures is practically unlimited. Many complementary measures have been attempted in the case study areas; many more are applicable to beltway influences, but have been utilized only for other purposes thus far. The effectiveness of any of these measures depends on local conditions—obviously, no amount of promotion will sell spaces in a strategically located industrial park if the market is glutted.

The array of complementary measures includes:

- Special zoning districts in the vicinity of the beltway and beltway interchanges. Baltimore County planners proposed such a concept in their 1968 Guidebook.

- The establishment of an urban service area boundary beyond which services will be provided only to a rural standard. An example is Minneapolis/St. Paul's Metropolitan Urban Service Area or MUSA line.

- Capital improvement programming and public facilities financing designed to minimize adverse fiscal effects on central cities. An example of this is found in Columbus' historical refusal to extend sewer and water facilities to developing areas unless annexed to the city.

- Joint development projects, such as the coordinated development of a regional center at a beltway interchange, combining both public and private uses and park-and-ride lots. In San Antonio and Baltimore there has been some joint use of beltway shopping center parking lots. In Atlanta, the MARTA system is being designed with stations to be built near beltway interchanges, but specific plans for joint development have not been formulated.

- Joint use of beltway right-of-way. No state highway departments pursued this option in the case study areas.[11]

- Special assessment districts and development charges to minimize public costs associated with private development. The Omaha case study illustrates shows how improvement districts located in unincorporated areas can foster scattered development and adversely affect city costs upon annexation.

- Regional tax revenue sharing programs established to compensate for intrametropolitan shifts in retail sales, industrial location, and housing. Such a system has been established, for property tax revenues only in the seven counties surrounding Minneapolis and St. Paul and is being implemented despite legal challenges.

- Downtown revitalization programs funded under HUD's Urban Development Action Grant (UDAG) program, the Economic Development Administration's (EDA's) Title IX program, and the Small Business Administration's loan guarantee programs. Examples are found in all case study cities.

- Impact zoning, incentive zoning, and regulations to effect downtown revitalization through achieving a balance of retail and office space downtown and concentrated headquarter activities downtown. The Minneapolis experience with its award-winning Metrocenter plan is illustrative of what can happen with strong planning efforts.

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11 For details, see Rivkin Associates, Inc. Acquisition of Land for Joint Highway and Community Development: Main Report and Case Studies (Washington, Federal Highway Administration, Report FHWA/SES-77/05 and FHWA/SES-77/06, 1976).

- Local downtown revitalization measures, including tax-increment financing, tax abatement, community development corporations, parking authorities, sports arenas, convention centers, and other activity generators. The Paseo del Rio, Hemisfair, and the convention center in San Antonio and redevelopment efforts in Columbus, Louisville, and St. Paul are good examples of this measure.

- Transit improvements which enhance accessibility to downtown. In Atlanta and Baltimore rail transit systems are being built, while Minneapolis and San Antonio have opted for improved bus service.

- Transit improvements which improve the accessibility of suburban facilities and employment opportunities to central city residents. Transit operators in Baltimore and Omaha initiated reverse-commute bus service from downtown and inner-city residential centers to industrial centers outside the beltway, (in Omaha this was later discontinued).

- Maintaining good relationships between planners and the local business community, encouraging private efforts at downtown revitalization, such as found in Atlanta (Central Atlanta Progress), Louisville (Louisville Central Area Committee), Minneapolis (Downtown Council), Omaha (Omaha Development Council), and San Antonio (Centro 21 and United San Antonio).

- Limiting access where the beltway traverses an environmentally sensitive area, providing for mobility across such an area without encouraging development. On San Antonio's outerbelt this might have avoided a potential threat to the groundwater aquifer.

Specific recommendations on selecting complementary measures to mitigate potential adverse effects and to enhance benefits are included in the Guidebook, a companion report. The guidebook presents an analytical framework for assessing specific beltway proposals, identifying and evaluating complementary measures, and making tradeoffs that will ensure that a beltway will be of net benefit to the region.

5. CONCLUSIONS AND POLICY IMPLICATIONS

PRINCIPAL CONCLUSIONS

Early Planning For Beltways

Beltway planning often was inadequate; alternatives rarely were evaluated comprehensively, and land use and infrastructure impacts for the most part were ignored. This is most clearly demonstrated in the detailed case studies showing little analysis of belt and corridor alternatives and no assessment of land use and transportation relationships. Prior research also pointed out this limitation. Only in Columbus were recommendations made to give first priority to interchange areas for annexation and to coordinate extension of water and sewer service with land use policies in the beltway corridor.

Transportation Effects

A beltway can be an important component of an urban highway system, providing an improved network for non-downtown oriented trips and for through traffic. Beltways offer cross-town connections between suburban communities that work particularly well where the radial highway networks mainly serve those working downtown or at outlying employment sites.

A complete loop beltway does not have marked different impacts or exhibit higher traffic volumes than a partial circumferential highway; location and interchange spacing are more important design features affecting land use and urban development in the belt corridors and in the metropolitan area at large. The experience in Louisville, Omaha and Raleigh where partial beltways are constructed is not significantly different from the other five case study areas which have a 360 degree circumferential highway. No threshhold effects were evident; traffic volumes did not increase greatly after final links were completed, nor have lightly traveled sections attracted much development once the loop is closed. Closely spaced interchanges and frontage roads do attract more development to a beltway corridor than widely spaced interchanges and no frontage roads simply because of the increased accessibility they provide. Distance from downtown was not found to be significant either in the comparative statistical analysis or in the detailed case studies.

Without coordinated land use and transportation planning, beltways can increase traffic on local streets and radial highways because of their effects on development patterns and the accessibility they offer. Beltway interchange areas have attracted traffic generating uses, such as shopping centers or office parks, pushing traffic volumes higher than originally anticipated. In some instances, interchanges had to be widened to relieve congestion.

Interchange location and corridor land use policies should be clearly defined in order to avoid unexpected land use impacts with adverse socioeconomic, fiscal, and environmental consequences. Highly accessible interchange areas offer attractive opportunities for commercial and industrial development; transportation planners should recognize this effect and plan accordingly. Land use planners should

coordinate with transportation planners to avoid creating opportunities for development which would conflict with local or regional policies or harm older business districts.

Effects on Land Use Policy and Urban Development Programs

Planners recognized beltways' potential influence on land use and development decisions, but policies proposed to manage corridor and interchange area development did not receive much political support. In part, this was because early planning requirements did not require a commitment to adopt and implement land use policies consistent with the policies and assumptions upon which transportation plans were based. Area-wide land use plans were sketchy and rarely carried statutory authority other than that conferred by the federal A-95 review process.

In none of the communities studied was the relationship between land use in the beltway corridor and downtown development policies analyzed, nor were plans with mitigation measures to compensate for potential adverse effects enacted. In Baltimore, Omaha, St. Paul, and San Antonio the effects of proposed outlying regional shopping centers near the beltway are of some concern, but no rigorous studies of urban impacts they might cause have been initiated.

Water and sewer service extension policies rarely were coordinated with beltway planning efforts. However, increased interest in growth management and the need to minimize infrastructure costs has prompted many of the governments to delineate development opportunities in beltway corridors with urban service area lines; examples of this are evident in Baltimore, Minneapolis, and San Antonio.

Annexation and infrastructure financing policies and the role of extraterritorial jurisdiction in land use policy have had far greater impacts on suburban development trends in beltway corridors then the mere presence of the beltway. This was most apparent in Columbus, Omaha, Raleigh, and San Antonio.

Effects on Regional Economic Growth

No strong evidence exists that beltways improve a metropolitan area's competitive advantage. Weak statistical relationships suggest a small, positive effect on population during the 1960s, but not the 1970s. No statistically significant relationship between the presence of a beltway and above average increases in manufacturing employment in the 1960s or 1970s was found. Differences in the value of manufactured products or in capital expenditures also were not statistically significant between beltway and non-beltway areas.

Effects on Development Decisions

A beltway may have a locational effect on multi-family housing; single family residential development patterns rarely are affected over the long run. Differences in housing patterns between beltway and non-beltway cities are not statistically significant. In fact, the greatest suburbanization occurred in metropolitan areas without beltways, even greater growth than was experienced in areas with suburban beltways.

A beltway can increase development opportunities in its corridor and reinforce prevailing urbanization patterns. However, it is not a sufficient inducement to counteract the effect of an area's poor image or to create a market for land, housing, or commercial and industrial space where none historically existed, as is shown by the slow pace of development along southern portions of I-410 in San Antonio, I-270 in Columbus, I-694 in Minneapolis, and I-680 in Omaha.

Beltway interchanges are favored locations for regional shopping center development, but many of these centers would be built in suburban market areas even if the beltway had not been constructed. Beltways appear to affect the timing, location, size, and initial success of these centers but are not critical in determining their overall feasibility.

Industrial and office park developers are willing to pay a premium for corridor and interchange area sites with accessibility to and visibility from the beltway. However, the presence of a beltway is less important than the availability of developable land and the accessibility to a skilled labor force. In most communities, radial highway sites with rail access were preferred over beltway sites for industrial park development.

Effects on Central Cities and Central Business Districts

Beltways can have a "one time" effect on the distribution of new office space in a metropolitan area that may weaken the downtown office space market, drawing some employment out to suburban locations that might have stayed downtown had the beltway not been built. In the case study areas, this effect was short-run in nature and did not harm central city revitalization efforts.

Historically, central cities surrounded by suburban beltways posted lower gains in retail sales and employment than those with beltways within their jurisdiction or those where no beltway was built. Changes in the central city population and work force were the most important determinants of central city retail sales.

Focusing just on retail activity in the urban core, the comparative statistical analysis showed that differences in 1967-77 sales trends in central business districts are not significantly different in beltway and non-beltway areas studied. The existence or location of a beltway is not a statistically significant factor after accounting for other influences, mainly changes in resident population and manufacturing employment.

The comparative analysis indicated that suburban beltways have a small, negative, statistically significant effect on employment in the wholesaling and service sectors of central city economies—a finding confirmed by the case studies. In Atlanta, Columbus, Louisville and San Antonio, warehousing and non-rail oriented distribution centers have clustered around beltway interchanges.

Changes in industrial employment in central cities show a small, but statistically significant negative relationship with the presence of a suburban beltway after accounting for other factors, suggesting that some fraction of the shift of employment within metropolitan areas between 1967 and 1972 could be attributed to beltways. The regression equation shows that city age has the strongest relationship

with the rate of central city manufacturing employment growth. Since central city manufacturing employment changes explained the most variation in central city population growth, it may be inferred that beltways have had an indirect effect on the central city population growth rates, although the analysis of population distribution detected no such effect at a statistically significant level.

The regression analysis of the proportion of the suburban labor force employed in the central city showed a distinct negative effect of a suburban beltway. However, this model had a low level of overall "explanation."

A shift of development activity to a suburban beltway corridor can affect the fiscal resources of a central city, especially if it lacks the authority or the willingness to annex developing land or does not have an aggressive revitalization and economic development program underway.

Downtown revitalization and economic development efforts involving both public and private sector commitments can more than compensate for any negative, short-term effect a beltway may have on the vitality of core areas. Successful convention centers also help as does a strong downtown office market.

Regional Consequences

Most economic and land use effects of beltways represent transfers of activity from one area to another within the same metropolitan area. This can affect the economic and fiscal health of individual jurisdictions unless compensating measures, such as tax revenue sharing, annexation, and growth management strategies are implemented. Examples of such an effort are found in Columbus, Raleigh, and San Antonio where aggressive annexation of developing areas enabled the cities to nearly quadruple in size between 1950 and the present.

By facilitating suburbanization of population and employment, beltways and other infrastructure investments in most instances confer no benefits on the disadvantaged and low income residents, many of whom live in central cities. Further, suburban beltways, by drawing activity out of central cities, affect their tax base and the cities' ability to deliver needed social services.

By attracting industrial development to outlying areas, beltways may reduce job opportunities for inner city residents. They also can provide access from blue collar neighborhoods to major employment centers (see Louisville case study). Finally, they can increase housing opportunities by attracting apartment development to the corridors they serve.

Beltways may increase total travel, but their effects on energy consumption are not necessarily negative, as they may provide incentives for nodal development, mixed-use centers for one-stop shopping and better transit. The statistical analysis of vehicle miles of travel (VMT) shows a significant positive relationship between VMT and metropolitan land area, beltway mileage, and negative relationship with transit capacity, but further research is needed to confirm whether and to what degree significant effects should be attributed to beltways.

In nearly all areas studied, beltways did not increase the rate of outlying residential development. In most communities, since beltways had no effect on overall development patterns, conversion of agricultural land and other environmental effects associated with suburban land development were no different over the long run than if the beltway had not been built. To the degree that beltways promote compact development patterns, they are preferable to other solutions to community land use and transportation needs that would allow scattered development.

POLICY IMPLICATIONS

The comparative statistical analysis shows that beltways can have small but significant effects on regional development patterns and the economies of central cities. The case studies demonstrate the need for more comprehensive planning, alternatives analysis, and community impact assessment to obtain the full benefits that beltways can offer and to minimize potential adverse consequences. At a metropolitan scale, beltways often have had unexpected, sometimes adverse consequences on land development. Complicating the picture are the jurisdictional issues: restrictions on annexation and the central cities' limited voice in metropolitan planning organizations. However, planning requirements alone will not ensure that local actions are consistent with national transportation and urban policy because there is little incentive for a city to adopt and implement land use and transportation policies consistent with national objectives.

Political support for land use planning and growth management still is not widespread, although its constituency is growing as the fiscal and economic benefits of careful management of urban resources and controlled development become increasingly evident. Rather than impose additional project review and impact assessment requirements on state transportation departments and local governments, the federal government might demand greater commitments to realistic plans and implementation programs, anchored in economic and political realities.

How this approach might enhance the benefits of beltways and minimize their potential harmful effects will become clear as the specific policy issues which surfaced during the case studies are addressed.

Planning Requirements: Alternatives Analysis and Coordination with Land Use Policy

Section 134 transportation planning requirements as well as environmental review procedures established by the National Environmental Policy Act and the President's Community Conservation Guidance all have established far more stringent standards than those which guided early beltway planning efforts. However, even today, outer beltway proposals are not subjected to much comprehensive study: corridor land use alternatives and their infrastructure requirements are not analyzed in detail, and the effects of alternatives to the beltway on development prospects, revitalization efforts, and fiscal conditions elsewhere in the metroplitan area are downplayed or ignored. (For details, see the Louisville and San Antonio case studies.)

One solution to this problem is for the federal government to provide local agencies with specific guidance on how to conduct an impact analysis. The Guidebook, published as a companion volume, responds to this need. Another possible solution is for the federal government to revise transportation and land use planning requirements to ensure that national urban policy objectives are addressed adequately.

Through its 701 planning requirements, HUD has the opportunity to monitor local efforts and to ensure consistency with national urban policy. Similar review procedures have been established for HUD's Community Development Block Grant Program. In neither case, though, are interjurisdictional land use, transportation, and development issues satisfactorily addressed. Area-wide land use plans usually are quite sketchy, particularly when prepared by voluntary associations with no statutory authority other than A-95 review. These plans do not provide a sufficiently detailed framework for analyzing shifts in development patterns and economic activity potentially caused by a circumferential highway. Further, the shift in emphasis in the 701 program for land use planning to three-year strategy statements and action programs may reduce community awareness of the long-range implications of transportation improvements if local planners merely examine consistency with national urban policy objectives in the short-term. The action program local governments will prepare may not provide HUD with sufficient information to gauge the consistency of local planning efforts related to beltway proposals and with national urban policies.

The urban impacts of federally funded highway construction or improvement projects rarely have been analyzed in terms of interjurisdictional effects, nor has the consistency of such projects with specific local land use plans, housing assistance plans, and community development programs. Consequently, neither federal agencies nor concerned local officials collect much evidence from which to decide whether their policies or programs might be compromised by a commitment to build a beltway. The President's 1979 Community Conservation Guidance allows mayors to request such an analysis, but careful attention early in the planning process would be more efficient. To accomplish this, DOT could require that, as part of the transportation planning process, corridor land use plans be prepared and adopted and include four components: (1) staged development plan, (2) urban service area program, (3) an analysis of impacts of the proposed beltway on community development, urban revitalization, and transportation improvement programs elsewhere in the metropolitan area, and the consistency of the project and the corridor land use plan with national transportation and policy, and (4) an action program including complementary measures to maximize a beltway's benefits and to minimize its potential adverse effects.

Interchange Location Policies

In Columbus, where the average distance between interchanges on the beltway is over two miles, traffic flow is smooth without peak hour congestion, accident rates lower, and corridor development not as intense as in other areas. Interchanges, built after completion of a beltway, may facilitate outlying commercial or industrial development that is inconsistent with local plans and that could adversely affect established centers or development commitments in other parts of the urban area. Some city officials in Omaha believe that an interchange proposed southwest of the city to accommodate a planned major shopping center will harm city retailing. To counter such possibilities, the federal government could require adoption of interchange location policies modeled on those used in Columbus during belt construction or those developed by the Twin Cities' Metropolitan Council. Approval of interchanges on a beltway should be given only after consideration of the following criteria:

- Consistency with regional and local land use plans;
- No significant impact on older urban areas or downtown revitalization programs;
- No significant impact on the rate of development in urban fringe areas;
- No significant impact on minority housing and employment opportunities;
- Non-interference with the operational integrity of the highway;
- No significant impact on level of service and traffic flow;
- No significant increase in energy consumption;
- Demonstrated need;
- Connection to a freeway, expressway or major arterial; and
- Compatibility with existing or proposed express transit service.

Connections to local arterials probably should be approved only on a case-by-case basis. Where intensive and uncontrolled development clusters around interchanges, it may be necessary to improve ramps and widen beltways well before expiration of the planning period, often with federal money. Federal refusal to support widening projects required by unplanned development might provide a financial incentive for stronger land use control at the local level. However, such a policy might entail unacceptable continued congestion. These issues and options should be addressed in any urban impact analysis requested under the Community Conservation Guidance.

If questions about potential adverse effects attributable to beltways have not been adequately addressed in the traditional planning and project review process, central city mayors should be encouraged to exercise their prerogative under the Community Conservation Guidance to request an Urban Impact Analysis. This is particularly important if a proposed interchange would directly facilitate construction of commercial or industrial development that could affect the vitality of older urban areas. HUD should ensure that guidebooks prepared for the department outlining procedures to follow in preparing an Urban Impact Analysis Statement contain explicit recommendations on analyzing the effects of interchange location policies on land use and urban development. Mitigation and enhancement techniques described in the Guidebook also should be considered by those preparing Urban Impact Analysis Statements.

Coordinating Transportion Planning with Capital Improvement Programming

By encouraging nodal development in suburban areas, beltways may indirectly decrease the need for new public facilities and increase use of existing infrastructure. However, beltways will not effect nodal development without supporting land use policies focusing development at selected nodes. Lax policies on suburban water and sewer extension development may increase suburban residential development, contributing to depopulation of central cities. Infrastructure expenditures improve the competitive position of suburban sites both within and outside the beltway corridor, working against the purpose of the federal assistance to central cities. Careful planning coordinated among jurisdictions with authority over land use in the beltway corridor is essential to avoid unexpected increases in the costs of federally financed infrastructure.

To ensure that urban freeways do not induce unanticipated demand for unprogrammed streets and utilities extensions, local governments should be encouraged to adopt urban service area programs and to designate areas for staged development. Development outside established limits might be permitted if consistent with the long range development plan and applicable environmental standards, and incorporating an acceptable financing plan. Such a plan might require the developer to pay the capital costs, operating and maintenance costs becoming a public responsibility. Within any corridor or expansion area, the cumulative impact of development on infrastructure requirements should be examined, rather than merely the immediate specific proposal. For example, a shopping center will probably induce further development entailing a greater load on local infrastructure. Without contingency planning, design capacities may be quickly exceeded, with serious adverse consequences.

Minimizing Adverse Effects on Development Patterns

Critics of beltways see them as a major cause of sprawl. Evidence from the case studies is mixed. Beltways can serve as a catalyst for nodal development, as illustrated by the Baltimore, Raleigh, and Minneapolis cases. They also can attract some activities--auto-oriented commercial uses, motels, subregional offices—to a highly accessible corridor or to interchange quadrants. This may be preferable to strip commercial development scattered out along radial highways, a position informants in Atlanta, Baltimore, Minneapolis, Raleigh, and San Antonio supported. Better corridor-level planning to capitalize on the urban form-giving potential is needed for a beltway to function as a mechanism to achieve compact development patterns and not a "sprawl-inducing" facility.

Minimizing Adverse Effects on Central Cities

To minimize potential adverse effects on central cities, local governments should plan for and control development in the beltway corridor so that major shifts in the location of development activity to the beltway corridor do not adversely affect regional market conditions for downtown development. Rather than competing for "ratables"—new, high value commercial and industrial development—by overzoning and offering costly incentives, such as immunity from annexation for five to ten years or no-cost utilities extensions, suburban communites should be encouraged to designate and zone only a ten or twenty-year supply of developable sites. To provide an incentive to do this, state legislatures should be encouraged to enact metropolitan tax revenue-sharing legislation to mitigate the effects of such shifts in development patterns. They also could establish a metropolitan planning and review process with statutory authority over major projects or impact assessment procedures modelled after those in the Community Conservation Guidance to require analysis of major development facilitated by state infrastructure investments, including state-financed beltways.

The beltway case studies suggest that central city officials have cause for concern about the beltway's effects, more so because of impacts on the location of offices than impacts on retail trade and shopping patterns. New regional shopping centers clearly can affect the vitality of retailing in older urban areas. A beltway is often an important determinant of mall locations and the accessibility it offers does contribute to a suburban center's financial success. However, beltways do not directly increase the market demand for additional retail space, the most important

determinant of the "need" for a new center, because they have little impact on the overall rate of suburban residential development.

The most severe impacts on downtown retailing have occurred with national stores and developers who, at least in the case studies, were less sensitive to local issues, more aggressive, and consequently, more likely to abandon downtowns than family-owned firms with strong civic ties. National retailers see their market in the suburbs and are only interested in downtown locations where office space is growing and local governments are willing to share in the financial risks by providing cleared sites and parking facilities.

Central city officials should be able to make a strong case for centralizing office space because of the advantages of core area locations. A prerequisite for successful implementation of this strategy is adequate access to downtown. To complement such efforts, suburban planners should take a close look at developable sites in the beltway corridor and recommend that land be zoned to meet corridor, not regional, needs. This should avoid drawing out firms that otherwise might have considered a downtown location or office space in older urban areas. Regional planners can play a role in the negotiation process by assisting in the analysis of how development strategies and beltway alternatives will affect the distribution of office employment, and the resulting effects on housing demand.

Minimizing Effects on Downtown Revitalization Efforts

Those concerned about a beltway's impact on downtown revitalization efforts can learn from the case studies. Only in Omaha might one conclude from superficial analysis that the beltway seriously jeopardized downtown redevelopment efforts, but a closer look reveals that lack of political leadership, a skimpy inventory of redevelopment tools until the very recent passage of enabling legislation, and permissive development regulations and financing arrangements favoring suburban growth were far more important factors. In the other cities, downtown planning and revitalization efforts have chalked up some successes; the failures are not attributable primarily to the beltways and their impacts on development patterns.

One of the most important findings of the case studies is that downtown development need not be based on massive public support, as the skylines of Atlanta and Minneapolis demonstrate. In fact, many of the case study cities are just beginning to explore use of redevelopment tools, such as tax increment financing, and to revise downtown zoning ordinances to incorporate density bonus provisions for public amenities and to require ground floor retailing in office buildings. Greater use of these mechanisms, coupled with efforts to reduce the disadvantages and high costs of core area locations, will make downtowns more attractive places to live and work and, consequently, enhance investment opportunities. These tools can be viewed as "compensating measures," counteracting the attractive sites in a beltway corridor. In most case study communities, close working relations with the private sector proved to be far more important in securing downtown development than any technical planning efforts—an obvious lesson for planners and elected officials seeking to minimize negative central city impacts indirectly related to suburban development.

Enhancing Job and Housing Opportunities for Minorities

Several beltway studies reported that employers located along beltways found it difficult to attract blue collar workers, presumably living in the central city. This suggests that their prior locations were more accessible to blue collar workers, and that the beltway may have reduced employment opportunities for workers who did not or could not follow the firm to a suburban location. However, by increasing overall metropolitan accessibility, a beltway could increase mobility to employment for many persons, including disadvantaged residents of small communities within the metropolitan area.

In several cases where recent data were available on travel patterns of blacks and whites, the evidence suggests that the urban highway system, including a beltway, meets the commuting needs of white workers better than it does for low-income black workers; blacks spend more time travelling shorter distances. Indirectly, by fostering suburbanization of some office space which in the absence of a beltway might have been located in core areas, beltways reduce job opportunities for inner-city residents, many of whom are members of minority groups.

To minimize some of these inequities, HUD should take a closer look at housing assistance plans prepared by communities potentially affected by construction of a beltway to ensure that (a) the analysis of those "expected to reside" in the locality reflects the opportunities that could be created by the beltway, (b) adequate provision is made for housing all income groups, and (c) affirmative marketing programs are initiated on a metropolitan basis, not just in the local community.

HUD also should use some of its discretionary funds to increase the amount of assisted housing available in a beltway corridor and to encourage construction of subsidized for-sale housing. Those planning for future beltways should carefully assess housing needs in the corridor and apply for supplemental assistance, where warranted. When controversies about a beltway's socioeconomic impact cannot be resolved at the local level, DOT, relying on the precedent established by the I-105/Century Freeway project, could assume a more active role in coordinating federal and local efforts to ensure that housing and job opportunities within any beltway corridor are available to those displaced by urban freeway projects and to inner city residents, particularly minority group members.

Because of their peripheral location, construction of beltways has caused little displacement of households and businesses, in marked contrast to radial freeway construction projects in central cities, many of which significantly disrupted minority communities. Thus, while beltways rarely benefit inner city minority populations, their construction also does not have direct adverse effects. Indirectly, they may reduce employment opportunities in older urban areas as they affect the distribution of economic activity, but the magnitude of this impact is not large and can be easily compensated for with inner city economic development programs.

Promoting Energy Conservation

While a beltway or other new transportation facility may induce some travel as well as possibly increase average trip length, it may also make some trips more efficient by reducing congestion and allowing travel at energy-efficient speeds.

The energy implications of different urban development patterns are somewhat uncertain, but a recent analysis for DOT concluded that a polynucleated city is more energy efficient than the traditional concentric ring city.[1] Based upon a theoretical analysis, the report states that while the amount of vehicle miles traveled is not substantially lower for the polynucleated city, the significantly lower congestion for work trips allows cars to travel at faster, more energy-efficient speeds. If a beltway can spur the growth of a polynucleated, or centers-oriented suburban development, it then may contribute to energy efficiency. Several of the case study areas, including Atlanta, Minneapolis-St. Paul, Raleigh, and San Antonio show some evidence of development of nodal sub-centers at beltway interchanges. Strengthening of these nodes may create strong centers large enough to make transit service viable.

Differences in energy consumption between cities and suburbs are not nearly as great as between low and high density development, transit-accessible and highway-oriented development, and close-in and outlying suburbs, according to an analysis conducted as part of the Brookings Institution's study of Urban Decline and the Future of the American City.[2] This suggests that nodal development will become increasingly prevalent with continued energy shortages.

If a circumferential highway is judged an essential component of an urban transportation system to promote compact growth and nodal development, local governments should be encouraged to promote beltway transit service, particularly where it can be designed to serve shopping centers, park-and-ride lots, and radial bus routes efficiently. A model for such service exists in San Antonio.

Baltimore planners suggested that careful corridor planning can achieve a balance between jobs and households, which will reduce trip lengths and facilitate carpooling--both energy saving measures. Beltway interchanges, particularly those with key radial freeways, are excellent sites for park-and-ride lots, both for use by transit and car or van pools. Park-and-ride lots should be designed in conjunction with the beltway.

Local governments have no strong incentive to make energy-efficiency a strong planning objective. In contrast to air and water quality planning where the standards to be achieved and maintained are clearly established, energy planning still is in its infancy; targets for conservation in urban areas have not been quantified, and tradeoffs between land use and transportation are of academic interest only, except in selected communities with innovative programs, Davis, California, and Portland, Oregon, being two examples. Therefore, state and local officials usually have no basis for judging whether a beltways' impacts on energy consumption are acceptable or unacceptable.

On balance, though, construction of an urban highway link will not have much effect on overall metropolitan or national energy consumption; decisions on transportation

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1 Robert Peskin and Joseph Schafer, The Impacts of Urban Transportation and Land Use Policies on Transportation Energy Consumption (Evanston: Northwestern University, from U.S. Department of Transportation Report No. DOT-TST-77-85), April 1977.

2 Kenneth Small, "Energy Scarcity and Urban Development Patterns" (Princeton: Princeton University Department of Economics, February 1980), p. 39.

improvements should not be made solely on the basis of their energy implications, although planners and decision-makers should be asked to seek the most energy-efficient solution.

Improving Environmental Quality

Since most existing beltways were built before current environmental legislation was enacted, little information was collected on the environmental effects of beltways. These recent requirements should reduce or mitigate environmental impacts of future beltways, but there still remains the likelihood that increased vehicle miles travelled resulting from a beltway could contribute to increased air pollution, and beltway-induced development may increase conversion of open space to urban use. The extent of these potential effects can only be gauged by comparing what could happen with a proposed beltway with development patterns likely to occur with alternative transportation improvements.

Implementation of effective interchange policies and planning requirements should improve local governments' understanding of the consequences of completion of a specific highway improvement. Then, given appropriate targets, such as air or water quality or an energy budget, tradeoffs can be made. If the facility is judged necessary from a transportation perspective, overall emissions or runoff rates can be kept within allowable limits by implementing other control measures. These might include a transit service improvement program, stricter controls on air pollutant emissions from stationary sources, treatment of runoff at outfalls or growth management plans. The issue from the federal government's perspective is how to achieve consistency between local actions and federal policies, not how to reduce travel in any specific area. With this in mind, local governments should be given considerable latitude in their planning and be encouraged to formulate innovative, but workable plans responsive to national goals.

A Summary Assessment

To conclude, much can be done to make beltways function as a positive, urban form-giving element in metropolitan areas. Where the transportation service they provide is needed, local officials working with the private sector and with state and federal agencies can formulate and implement workable plans that should ensure that beltways have few, if any, adverse impacts on urban areas. The initiative for such planning should come from local jurisdictions, but the federal government can assist in these efforts by offering technical guidance and financial aid to agencies planning and implementing programs to enhance the benefits and to minimize or eliminate harmful effects.

Policies and programs proposed in this chapter are intended to improve coordination between transportation planning and land use planning and capital improvement programming. Those concerned about downtown can do much more than they have done to make core areas viable and attractive places to live and work; opportunities for minimizing or eliminating potential negative effects directly or indirectly attributable to beltways exist. If beltways are to be accepted as a net benefit for metropolitan areas—and all proposed beltways may not meet such a test—then their urban impacts need to be understood and commitments made to supporting land use policies and other required compensating measures. If this is done, beltways may support attainment of energy-efficient and environmentally sound settlement patterns—a major objective of national urban policy.

APPENDIX A. GENERAL REFERENCES

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33. Nourse, Hugh O., (Gardener ed.), "Industrial Location and Land Use in Metropolitan Areas", from America's Cities, Michigan Business Papers, No. 54, Ann Arbor, 1970.

34. Owen, Wilfred, Transportation for Cities: The Role of Federal Policy, Brookings Institution, Washington, D.C., 1976.

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This review of the literature indicates that while various methods exist to determine a community's competitive advantage (i.e., export base, shift-share and economic profile techniques), each of these methods contains certain limitations which restrict their usefulness for local and national officials. It includes an analysis of supply side factors.

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APPENDIX B. LAND USE AND LOCATION THEORY

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APPENDIX C. BELTWAY IMPACT STUDIES

Major References

1. Bone, A.J., and Martin Wohl, Economic Impact Study of Massachusetts Route 128, Massachusetts Institute of Technology Transportation Engineering Division, Cambridge, Mass., 1958.

Objectives: The purposes of this study were (1) to investigate land use changes, (2) to determine the basic factors causing such changes, and (3) to evaluate the traffic-generating characteristics of the industrial development adjoining the highway.

Methodology and Variables: Representatives of 96 firms were interviewed, representing distribution, production, research and development, and services categories of employment. An employee survey was conducted to determine the travel characteristics of workers along Route 128. In order to evaluate the net effect of the facility on employment and investment, a separate use survey was undertaken of sites formerly occupied by beltway firms. The effects of industrial property taxes on tax rates in one community, and trends in residential assessed values, building permits, housing densities, and real estate sales over a 12 year period (using a control area in each community studied) also were examined.

Findings: The authors estimated that the metropolitan area had gained 80 million dollars of new industrial development along Route 128 by September 1957, with addition of approximately 12,000 new jobs. The central city lost approximately 1,500 jobs. The authors further stated the shift was still underway and an additional 50 percent increase in investment and employment was anticipated for 1958. Timing was considered to be a key exogenous variable, as the highway made suburban land more accessible at a time when many Boston firms were expanding to a point where they could no longer operate efficiently in older buildings in the central business district.

The survey found that the key reasons for selecting Route 128 sites were: land for expansion, the labor market, employee access, and commercial access. However, firms that employed large numbers of unskilled or part-time labor found it difficult to attract workers at the Route 128 location, primarily based on distance from the central city and lack of transit availability. At one industrial park, a survey showed that 47 percent of the employees had to shift to private automobiles from transit or walking as a prior mode when their workplace was in Boston. Although approximately 70 percent of the firms locating along Route 128 formerly were in Boston, the majority of their old facilities were re-occupied by smaller expanding firms, mostly using more space per employee. Approximately five percent of the old facilities were demolished for road or renewal projects, indicating push factors as well as pull factors in the move decision.

The findings of impact on residential property and development patterns showed that the highway had a less consistent effect, although the authors did conclude that it resulted in an increased rate of development near interchanges.

Critique: This study is marred by an assumption that most industrial development was a result of the existence of the highway. In fact, much of what occurred reflects the consequences of industrial expansion during a growth period and a shortage of available sites in Boston. Although firms were asked why they selected their new sites, they were not asked why they left their prior location, and the "push" factors may have been as strong or stronger than the suburban and beltway "pull" factors. In fact, a question about what other sites the firms considered showed that few contemplated relocating in the city of Boston (only 14 percent), and only 15 percent considered locating outside the metropolitan area. Thus, most firms probably would have relocated in the same or other suburban locations in the absence of the beltway. The resulting pattern of industrial development may be preferred from a planning perspective to suburbanization under a no-beltway scenario, but this issue was not examined. Further, about 50 percent of the total investment and employment growth along the beltway was located near the interchanges of major radials connecting the beltway to Boston, suggesting the entire highway network, and not just Route 128, was the key transportation determinant of site selection. Prior residential suburbanization, facilitated by radial highway construction, encouraged suburbanization of employment, but this was not evaluated.

2. Connally, Julia, The Socio-Economic Impact of the Capital Beltway, University of Virginia, Bureau of Population and Economic Research, Charlottesville, Virginia, 1968.

Objectives: This study sought: (1) to assess the extent to which changes in population, land use, real estate activity, and traffic volumes could be attributed to the Capital Beltway; (2) to investigate the impact of the Beltway on industrial locating and commuting and shopping patterns; and (3) to study how the beltway has influenced decisions made by local officials, realtors, and businessmen. (p.2)

Methodology and Variables: The two major techniques of analysis used were before-after time series analysis of 1950-66 statistical data (population, land use, traffic volumes, retail sales, etc.), and surveys of apartment dwellers, workers, shoppers, and representatives of industrial firms locating along the Beltway. Statistical tests were not used to confirm or refute hypotheses of potential beltway effects, and no overall measurements of beltway impacts were calculated.

Findings: The author concluded that the Beltway did not alter development trends, but rather reinforced existing trends or reoriented general development patterns that were already underway. Suburbanization of housing, industry, and retail facilities occurred well before the Beltway and aggregate patterns were not substantially affected. Multi-family housing and industrial development apparently clustered around Beltway interchanges because of the accessibility—a finding confirmed by interviews with residents or managers of industrial firms.

Critique: The report would have been stronger if it had included analysis of the effects of the Beltway on Washington, D.C. By focusing primarily on a 3-mile wide corridor, the investigators may have missed those detrimental transfer effects which did occur (less development in areas lacking accessibility). Based on survey results, one can infer that the Beltway did not have a strong effect on Washington, but this is

never stated. Only 10 percent of those who considered the Beltway a factor in job selection formerly were employed in the District, while only 4 percent of sampled Beltway apartment dwellers had moved from the District of Columbia.

Finally, the Beltway was completed in 1964, the statistics were available through 1965 or 1966, and the surveys were conducted in 1966. Over this short period of operation, some trends or effects may not yet have been apparent. A longer monitoring period would be required to identify long-term effects.

3. deLeon, Peter, and John Enns, The Impact of Highways Upon Metropolitan Dispersion: St. Louis, Rand Institute Paper Number P-5061 (Santa Monica, California), 1973.

Objectives: This paper addresses the relationship between highway improvements and changes in urban form in the St. Louis metropolitan area by testing the hypothesis that recently completed radial and belt highways decreased travel times to suburban areas, thereby influencing industrial employment location. This allowed a number of firms and industries to leave the congested central business district and to establish new facilities in the suburbs without incurring additional transportation costs.

Methodology and Variables: The basic method of analysis was to use descriptive statistics as well as simple regression models designed to explain variations in land use change as measured by changes in employmnent and population density. The impact of both radial and belt highways was examined:

> The distribution between radial and beltway highways is important because their respective impacts on employment location decisions may be decidedly different. The construction of high speed radial routes allows for increased accessibility measured in travel time between the established CBD and regions beyond the urbanized city-county ring. This increased accessibility, combined with the relatively inexpensive land available in outlying areas, provides a strong impetus for firms and households to locate farther from the CBD on land adjacent to the new highway corridors. By contrast, the Interstate beltway provides improved accesibility between various sub-regions of St. Louis County, thus encouraging new residential and employment location clusters to occur in concentric ring patterns emanating from the previously established urban boundary. (p. 7,9.)

The dependent variable used for the regression analysis was change in industrial employment density, expressed as employment per industrial acre using 1965 and 1970 as the time period. Independent variables used in the analysis were accessibility changes (to the CBD for radials and to all zones for the beltway) and the initial employment density in 1965 (under the assumption that the greatest change or increase in employment would occur in those zones with initially lower densities).

Findings: Analysis of land use density data for 1965-1970 confirmed the general trend of population and job dispersion from the central city, an exception being commercial employment density, which increased in the central city during this

period. The regression analysis demonstrated that radial highway improvements which reduced travel times from the CBD are significantly associated with increases in industrial employment density in the southwestern portion of the SMSA. Finally, testing for the influence of the beltway, the authors found that increases in accessibility to the labor force (represented by population density) resulting from the beltway were directly related to increases in industrial employment density.

Critique: This study only reviews employment density changes between 1965 and 1970, a rather short time period, complicated by the completion of several freeway segments between 1961 and 1972. Limited data availability, particularly on employment, makes it difficult to use more appropriate time frames in conducting such research. While the authors readily point out that many factors besides accessibility influence land use and density and that a comprehensive analysis would include such variables as income, lot size, undeveloped land value, and existing type of employment, for example, omitting such variables prevents use of a multi-variate statistical approach. This would provide additional information about the relationship between the independent variables and whether accessibility improvements are co-variant with or independent of other influences. Such an analysis was beyond the scope of their study, but would have represented a useful extension of the research.

4. Khasnabis, Snehamay, and Willard Babcock, Impact of a Beltline Type of Freeway Upon a Medium-Sized Urban Area in North Carolina: A Case Study (Raleigh, N.C.: University of North Carolina), 1975.

Objectives: This paper sought: (1) to evaluate the impact of a beltline highway upon land use, traffic, and the environment; (2) to develop predictive models for highway planners to assess the long range impact of a proposed highway upon the land development; and (3) to provide guidelines that will aid the planner to understand better the impact of a highway upon the total urban environment.

Methodology and Variables: Data were collected on construction of all new housing between 1961 and 1970, as well as new retail commercial, industrial, and office and institutional developments with an assessed value of $50,000 or more. Two techniques of analysis were used. The first consisted of a set of percentile graphs, plotting the development by distance from a beltway interchange. The second technique was multi-variate regression analysis. In the regression formulation, the number of units or assessed value of improvements was the dependent variable, and distance from the interchange, available vacant land, and a weighted zoning index were the main independent variables.

Findings: Both the percentile graphs and the regression analysis suggest that the beltway was a significant factor in the location of all types of residential, commercial, and industrial development within the Raleigh SMSA. Changes in traffic volume over time illustrated the concentration of activity occurring near the beltway. The authors concluded that:

> -The beltline was and remains as a greatly needed artery for the City of Raleigh.

-The beltline has been instrumental in increasing value of adjacent property.

-The changes in zoning that occurred because of increases in land values, and the unanticipated land developments have caused serious traffic problems at major interchanges in the urban area.

-The beltline's impact on the growth of the area has made many of the residential streets inadequate.

-The beltline has had a significant impact in decentralizing major urban activities from the core area; it does not appear that the core area can ever be redeveloped for shopping or retail activity. Obviously land values have gone down significantly in the CBD core, resulting in a substantial loss in the local tax base. An evaluation as to whether the effect of such decentralization has been detrimental or favorable will require further research.

-Finally, the beltline is considered to have had very positive effects on the growth and development of Raleigh, notwithstanding any adverse effects of decentralization. It generally represents an effective use of planning coordination between the city and private developers. (p. 26.)

Critique: The two strengths of this paper are the use of a longer time period of analysis following beltway completion (11 years rather than the customary two to five years), and the use of multi-variate regression, introducing other important variables of land use besides distance to the beltway. While the paper concludes that the beltway had a significant negative effect on downtown core land values and retailing activity, this is not documented by any analysis. A technical limitation of the regression model of office and institutional development patterns is that downtown office buildings were excluded from the data set, thus biasing the analysis to support the hypothesized model. Finally, while the benefits to the area as a whole may be significant, this paper ignores the distributional effects and the implications of decentralization.

5. The Urban Institute (Muller, Thomas et al.), The Impact of Beltways on Central Business Districts: A Case Study of Richmond, Washington, D.C., April 1978.

Objective: The main objective was to determine whether the development of I-295, a beltway proposed around Richmond, Virginia, would have an adverse impact on the central business district.

Methodology and Variables: To simplify and structure their research efforts, the authors narrowed the evaluation of likely beltway effects on an examination of the extent to which the beltway could encourage retail stores to leave the CBD for locations in shopping centers near the beltway. This possibility was analyzed by comparing trends in beltway and non-beltway cities. Traffic growth also was projected using more technical and socio-economic factors than employed in the beltway needs analysis prepared by proponents of the highway.

Findings: The Urban Institute study concluded that:

- Regardless of whether the beltway is constructed, movement from the urban core is expected to continue, although at a lower rate than in the 1960s and early 1970s.

- The facility will have no effect on the aggregate economic activity in the region. Economic effects will be limited to shifts in the location of business firms and housing within the region.

- A shift of sales and retail trade employment from the CBD to locations near the beltway interchanges can be anticipated if the Richmond Beltway is constructed.

- The beltway is not likely to be heavily used or to have a significant effect on the level of traffic congestion in the other parts of the road system due to the beltway's location in a thinly populated area far past the limit of the current urbanized area.

- Projected traffic volume forecasts are unreasonably high and not likely to be attained. Average trip length appears to have been significantly overestimated, since shorter trip distances could result in substantial reductions in anticipated total traffic.

- The additional consumption of gasoline resulting from use of the beltway as a bypass would be substantial, and thus contrary to the national policy of energy conservation.

Critique: While the Urban Institute study did compare beltway and non-beltway SMSAs of similar growth rate, the size of the sample (with only three in each category) leaves the reader questioning whether the data really prove the hypothesis, or the sample was selected to confirm the hypothesis of increased retail decentralization resulting from beltways. The three non-beltway SMSAs are not good choices for analysis, as two of the three appear to have circumferential highways (Louisville and Rochester), while the third is precluded from having one by its unique geographical setting (New Orleans). The conclusions of the economic analysis and the conclusions of the transportation needs analysis are not wholly consistent. On one hand, the beltway will draw retail development from the downtown; on the other hand, the travel and traffic volume forecasts for the area and for the beltway are unreasonably high. Finally, in analyzing the relationship between beltways and successful new large shopping centers, the authors do not indicate whether fewer shopping centers were built in non-beltway SMSAs or whether the same proportion of new centers were built focused on radial freeways instead.

6. Smith, Wilbur and Associates, Maryland Capital Beltway Impact Study: Washington SMSA and Maryland Counties, Columbia, S.C., 1968.

Objectives: The major goal was to evaluate the effects of the Capital Beltway on urbanization patterns, primarily those within the Maryland suburbs (Montgomery and

Prince Georges Counties). As with the parallel Virginia study (Ref. 2), the impact study covers the period up to 1965, one year beyond the completion date of the Beltway. Subjects investigated include effects on economic base, industrial areas, recreational activities, institutional activities, work trips, business centers (retail), residential property values, land use, environmental factors (primarily noise), traffic, and specific interchange areas.

Methodology and Variables: Three main methodologies were employed: analysis of time series trends and projections based on prior trends, quantification and projection of survey resuls, and formulation and application of a predictive mathematical model. The models of population and traffic used population holding capacity and accessibility as the most important independent variables. The accessibility changes resulting from the Beltway were used to project the net difference in 1976 population distribution resulting from the Beltway.

Results: The report concludes that the major contribution of the Beltway was to increase the accessibility of the entire metropolitan area, particularly the suburbs, to all other parts. Overall, the authors anticipated that the Maryland counties will gain slightly and that Washington, D.C. will lose population (.4%) employment (1.5%), and retail sales (1.3%) as a result of the Beltway (1976 distributions with versus without the Beltway). Traffic noise at night was a problem for some nearby residents; no other environmental problems were identified. The authors caution that Washington, as a result of its large governmental and small manufacturing sections, is not a typical metropolitan area, which limits the transferability of their findings.

Critique: Positive aspects of this study include the use of environmental factors (noise), case studies of selected interchange areas, and use of a model for predicting changes in land use attributable to the Beltway. This latter technique was an effort to compensate for the short time period for data collection following beltway completion. The report ignores the consequences of decreased population and employment in Washington. Again, by inference one concludes that the benefits of beltways to the suburban comunities must outweigh the detrimental effects on central cities, since the authors strongly state the Beltway has been a valuable addition to the metropolitan area. In one specific final comment, the authors present the model projections without sufficient discussion of the statistical significance of the results. In fact, the standard deviation of the model was such that the model is suggestive at best.

7. Thompson, Russell, William Atkins and Dan Davis, Preliminary Study of the Economic Impact of a Section of San Antonio's Loop 13 Expressway, Texas Transportation Institute, June 1960.

Objective: The objectives of the Loop 13 Study were (1) to ascertain changes in land values and in use as a result of the Loop, (2) to determine the attitudes of residents and businessmen relative to the advantages and disadvantages of the Loop Expressway, and (3) to determine the travel characteristics of those persons who reside in the vicinity of the Loop. Some of the objectives were not met as the study was completed during a period of site acquisition and construction.

Methodology and Variables: Data was collected and tabulated to show the prices of raw land and finished residential lots, adjacent to the old road and the new expressway. Differences between properties abutting and several blocks away from the expressway also were examined. Finally, an attitudinal survey among residents and businessmen to obtain opinions about the Loop's effects upon property values and the attractiveness of comercial sites.

Findings: While the relative accessibility of land along the Loop would be improved by completion of the expressway, during the construction period there was little indication of the road's economic impact. In fact, land values increased faster along the old road between the two periods than along the new road, but the greater percentage in the older area is attributed to developments such as the San Antonio International Airport and the attraction of several important lateral streets.

As a group, the residents interviewed had a favorable attitude towards the Loop; however, residents whose property abutted a frontage road had more concerns about traffic and noise (they were affected by construction dust and noise), while those several blocks away saw the potential accessibility benefits but suffered few of the disbenefits. Owners of businesses located in the study area viewed the Loop favorably; however, none of these were located on the "new road" segment per se. Finally, the growth rate in residential housing starts seemed to be greatest along part of the "new road" segment, probably due to land availability as well as the anticipated improvement in access.

Critique: Much of the land impact analysis was oriented to parcels adjacent or near the Loop; effects on the remainder of ;the metropolitan area were not addressed, nor were potential effects of employment, retail sales, or population dispersal gauged. As an early beltway study, it provides information on development of research techniques over time. The study should not be compared to studies of metropolitan effects conducted in the 1970s when research questions and techniques were considerably more fully-developed.

8. U.S. Department of Transportion, Federal Highway Administration, Office of Policy Planning, Economic and Demographic Forecasting Team, Suburbanization and Beltways: (Interim report on Beltway Impact Study), May 1972.

Objectives: The main objective was to determine the relationship between beltways and metropolitan growth patterns.

Methodology and Variables: Three categories of metropolitan areas were selected; a sample of 7 beltway areas, 7 non-beltway areas, and 13 other SMSAs (comparison group). The beltway and non-beltway SMSAs were selected in pairs based on population size, economic function, and per capita availability of automobiles. Population data was collected for 1950, 1960, and 1970, for the central cities, outside central cities (remainder of SMSA), and the non-SMSA portion of the Functional Economic Area. Other data analyzed included trends in the number of retail establishments and retail employment, and freeway mileage and urbanized land area. Trends in beltway SMSAs, non-beltway SMSAs, and the other SMSAs were tabulated.

Findings: The report does not present strong conclusions, but suggests that a prime impact of beltways appears to be the "attraction of rural growth into the SMSA rather than pulling growth from the SMSA as is generally thought to be the case." The data suggest that the growth rates of beltway SMSAs were greater than the non-beltways from 1960 to 1970, while growth trends had been similar during the 1950-60 period. Growth in beltway SMSAs did not appear to be at the expense of the central cities, as central city population and retail employment did not decline as quickly in the beltway SMSAs as in the non-beltway sample.

Critique: The report cites two limitations of the analysis. First, employment data was not tabulated; and second, no statistical tests were conducted to determine whether differences between beltway and non-beltway SMSAs were significant.

With the benefit of retrospect and the opportunity to have reviewed other beltway studies, several other limitations are apparent. Reviewing a recent atlas, the investigator's definition of a beltway is not clear, as it appears that several of the non-beltway SMSAs now have beltways and had them (or portions of them) in 1970 (Omaha, Louisville, Toledo, and Cleveland). It appears that central city population change was measured keeping borders constant, rather than incorporating annexations. If so, this should have been reported in the text.

The pairing of SMSAs by size and economic function is helpful. However, if the goal is to determine whether the location of growth is influenced by a beltway, it would be essential to compare locational growth trends in areas growing at a similar pace. The average SMSA population growth between 1960 and 1970 was 24.5 percent for the beltway areas in comparison to 12.8 percent for the non-beltway SMSAs. Given the growth data in this report, one must conclude that either (a) beltways affect the overall growth rate of an SMSA, or (b) that beltways were built in SMSAs that were expected to show strong growth in the 1960-70 period. More recent studies suggest a beltway effect ;on intro-metropolitan growth patterns but not inter-metropolitan shifts in growth.

Strengths of the analysis include the use of Functional Economic Area data, an attempt to measure effects beyond SMSA borders, and the use of data from a 20-year period, in contrast to many studies of highway impacts which only cover 2 to 4 years after project completion.

Other Studies

1. Bochert, John R., Beltline Commercial and Industrial Development Study in the Minneapolis-St. Paul Metropolitan Area, University of Minnesota in cooperation with the Minnesota Highway Department, U.S. Bureau of Public Roads, Minneapolis, 1960.

   A comparative study of the present and proposed beltline routes on the west side of the Twin Cities metropolitan area.

2. Langley, C. John, Jr., "Adverse Impacts of the Washington Beltway on Residential Property Values," Land Economics, pp. 54-65, 1976.

3. Levitan, Don, Massachusetts Route 128: A Nonemulative Enigma, Transportation Research Board, Washington, D.C., 1976.

This paper describes the 40 year period from 1925 to 1965 during which plans were originally developed for 128, the highway was built, and then later widened to handle increasing traffic loads. In contrast to the findings of the Massachusetts Institute of Technology study, the author concludes that economic development associated with this roadway was part of the developmental forces operating in the Boston urban area rather than a benefit from the roadway itself.

4. Maryland State Roads Commission, Economic Impact Studies 1960.

This document examines the effect of the Baltimore Belt on freeway construction sales, subdivision activity, and individual conceptions. Included are maps showing 1952 and 1960 land use and data on a sample of property sales in a Beltway area and a control area.

5. Massachusetts Department of Commerce and Development, Future Development of Eastern Massachusetts Route 495 and Fringe Area, 1963 and 1975-1990, Boston, 1967.

An examination of a circumferential highway passing through urban and rural areas and connecting with several radial highways is examined using the EMPIRIC land use forecasting model. Impacts of two alternative highway plans are examined based on two growth patterns - nodal and low density.

6. National Capital Parks and Planning Commission, Moving People and Goods, Washington, D.C., 1950.

This study advocates ring routes as the basis for the regional plan.

6. Ojala, Carl F. and Paul F. Rizza, "Route 128: A Study of Industry Location Factors," Atlanta Economic Review, pp. 36-39, 1970.

7. Theil, Floyd, "Beltway and Tax Base Impact," Journal of the Urban Planning and Development Division, American Society of Civil Engineers, pp. 105-117.

APPENDIX D. OTHER HIGHWAY IMPACT STUDIES

1. Adkins, William, "Economic Impacts of Expressways in Dallas and San Antonio," Traffic Quarterly, pp. 333-345, July 1959.

   This article summarizes radial highway economic impact studies on the Dallas Central Expressway and the San Antonio downtown expressway. The studies were before-after time-series analyses of effects on land prices, using control areas to measure expressway effects.

2. Buffington, Jesse L., "The Economic Impact of Interstate Highway By-Passes," Texas Transportation Research, pp. 2-6, 1968.

3. Care, Chester P., Influences of Interstate Highways on Plant Location in Kentucky: A Survey of Executive Opinion, Department of Resources and Transport Economics, American Trucking Association, Washington, D.C., 1967.

4. Donnelly, Robert M., Freeway Controversies and Their Implications for Transportation Planning: Cedar Rapids, Iowa, A Case Study in a Small Metropolitan Area, Technical Report No. 48, Institute of Urban and Regional Research, Iowa City, 1975.

5. Gamble, Hays B., Owen H. Sauerlender and C. John Langley, Adverse and Beneficial Effects of Highways on Residential Property Values, Transportation Research Record, No. 508, pp. 37-48, 1974.

6. Garrison, William L., et. al., Studies of Highway Development and Geographic Change, University of Washington, Seattle, 1959.

   A treatise in economic geography. A general discussion of the role of transportation is followed by an analysis of the benefits of highway improvements. The spatial arrangement of retail business with respect to highways is then examined in detail. The influence of highways on residential site selection is treated both theoretically and empirically.

7. Hammer, Siler, George Associates, The Influence of Central City Radial Freeways on Manufacturing Location Decisions, U.S. Department of Transportation, Federal Highway Administration, Washington, D.C., 1973.

   Case studies of the following cities: Hartford, New Haven, Chattanooga, Atlanta, Fall River, Providence, Nashville, and Winston-Salem. Radial freeway influence is found to be positive in revitalizing existing, declining central city industrial areas; strengthening existing, stable industrial areas; and developing new industrial areas.

8. Horwood, Edgar M., and Ronald R. Boyce, Studies of the Central Business District and Urban Freeway Development, University of Washington Press, Seattle, 1959.

   A discussion of the spatial organization of the central business district (CBD) as defined by previous research in this field, and establishment of an analytical framework to evaluate change related to urban freeway

development based on defined Central Business District "core" and "fringe areas. Measurements of CBD change and decentralization are examined.

9. Horwood, Edgar M., Carl A. Zellner, and Richard L. Ludwig, Community Consequences of Highway Improvement, National Cooperative Highway Research Report 18, p. 37, 1965.

   This summary report (Volume I) presents the evaluation of existing studies and four case history studies. Three types of studies are used: bypass, urban circumferential, and radial. Case studies are of Mohawk Valley, New York; Piedmont Crescent, North Carolina, Los Angeles, and Los Angeles intersections and Seattle highway corridors. Good bibliography.

10. Huhtanen, Robert J., et. al., A Study of the Effects of Freeways on Central Business Districts, Clark University, Worcester, Mass., 1961.

    Discusses land use, land value, access, and travel patterns. Three case study areas are examined (Richmond, Virginia, and Long Beach and Oakland, California), and the author uses land use mapping techniques for impact analysis.

11. Kentucky, University of, Bureau of Business Research, College of Commerce, Certain Economic Effects of the Lexington Northern Beltline, Lexington, Kentucky, 1960.

    An appraisal of the impact on land use and values of a 6-mile free-access bypass, built primarily for the relief of traffic congestion in downtown Lexington, Kentucky. Actual land use is compared with the probable land use in the absence of the highway. Changes in land use were considerable.

12. Kuehn, John A., and J.G. West, "The Ozarks: Highways and Regional Development," Growth and Change: A Journal of Regional Development, Vol. 2, pp. 23-28, July, 1971.

    An overview of highway development in depressed areas and a contribution to the debate over whether highways should be the major focus in regional planning. Highway type is related to type and amount of industrial employment in the Ozark region.

13. Ludwig, Armin K., et. al, University of Nebraska Center for Applied Urban Research, Radial Freeways and the Growth of Office Space in Central Cities, U.S. Department of Transportation, Federal Highway Administration, Washington, D.C., 1977.

    Seven metropolitan areas were studied to determine the impact of freeways upon the location of office development and to estimate the economic impact of this development upon the community. Findings indicated a sub-urbanization of office space. New locations were heavily influenced by radial freeway corridors although circumferential corridors were proportionately more attractive. Suggests that office development is an eminently suitable land use for radial freeway corridors. Case study areas included: Louisville, San Jose, Dallas, Atlanta, Denver, Omaha, and Minneapolis-St. Paul.

14. Miller, Theodore K., Freeway Impact in Milwaukee, Milwaukee Urban Observatory, Milwaukee, Wisconsin, 1972.

15. Moore, C.T., A study of the Expected Economic and Social Impact of Interstate Highways in the Industrial and Commercial Trading Area of Birmingham, Alabama, Alabama Highway Department, Final Report, 1965.

An examination of possible impacts resulting from completion of the Interstate Highway System in Birmingham, Alabama. Impact areas addressed include: manufacturing; retail trade and service industries; transient-oriented businesses; land use; and social impacts.

16. North Star Research and Development Institute, The Economic Impact of the Freeways on the Twin Cities Metropolitan Area, Minneapolis, 1971.

An examination of six impacts (land use, retail trade, residential property values, tax patterns, commercial and industrial freight, and community changes) of three Interstate segments of the Twin Cities' Freeway System. The highways examined include radial and circumferential freeways; were constructed from 1960 to 1968; and traverse both urban and suburban areas.

17. Pendleton, William C., "An Empirical Study of Changes in Land Use at Freeway Interchanges," Traffic Quarterly, pp. 89-100, 1965.

18. Urban Systems Research and Engineering, Inc., The Growth Shapers: The Land Use Impacts of Infrastructure Investment, Council on Environmental Quality, U.S. Government Printing Office, Washington, D.C., 1976.

Covers such facilities as water and wastewater systems, power supplies, highway and secondary road networks, mass transit systems, and airports. Medium -size bibliography. Many maps. Non-technical approach.

19. Wang, Pai-kang, George L. Patterson and Joseph L. Schofer, "Population Change: An Indicator of Freeway Impact," Transportation Engineering Journal, August 1975, pp. 491-504.

20. Wheat, L.F., "Effect of Modern Highways on Urban Manufacturing Growth," Highway Research Record, Number 277, 1969.

An attempt to determine whether cities with superior intercity highway connections enjoy more rapid manufacturing industry growth. Manufacturing growth rates from 1958 to 1963 are compared for two groups of cities, an experimental group located on Interstate System freeways, and a control group located elsewhere. The two groups were comparable in all major aspects except highways.

21. Winfrey, Robley, and Carl Zellner, Summary and Evaluation of Economic Consequences of Highway Improvements, National Cooperative Highway Research Program Report 122, Washington, D.C., 1971.

This report discusses the theory, concepts, and methodology of the economic and social consequences of highway improvements. Particular attention is given to the relationship of highway transportation to the social and economic community changes that may result from the improvement of

highways. It summarizes nine other National Cooperative Highway Research Program research reports dealing with the subject, and contains an extensive bibliography.

22. Witheford, David K., "Highway Impacts on Downtown and Suburban Shopping," Highway Research Record, Number 187, pp. 15-20, 1967.

Assesses the relative decline of trade in the central business district. Market areas within equal travel times of each shopping area are compared and reassessed after a metropolitan transportation improvement program increases the equal travel time radii by a constant amount. Buffalo, New York, is used as a test case. The analysis shows that highway improvements favor suburban shopping areas.

APPENDIX E: FOREIGN EXPERIENCE

1. Darry, Michel, Transport and Urban Development in the Paris Region, Proceedings of a Symposium on Transportation and Environment: Policies, Plans and Practice, Southampton University Press, Southampton, England, 1973.

2. Dawson, R., Environmental Effects of Alton Bypass, Transportation and Road Research Laboratory, Report LR589, Crowthorne, England, 1973.

3. Delayque, Michael, The Linkage Effects of Transport Infrastructure: Tentative Study of the Impact of the Rhone Valley Motorway on the Regional Economy and Level of Activity, Report of the Fourth Round Table on Transport Economics: The Impact of Infrastructural Investment on Economic Development. European Conference of Ministers of Transport, Paris, n.d.

4. Feuchtinger, Max - Eroich, The Traffic Study Concerning the Arterial Road System in the Munich Area, International Course in Traffic Engineering Report, 1954.

   A study to determine to what extent traffic in the Munich region would be affected by three projected facilities: Autobahn ring around edge of city; remodeling urban streets which encircle inner areas; and expressway systems at edge of inner area.

5. Greater London Council, M25: Effects on London, Greater London Council, London, 1978.

   Evaluation of the consequences on London of the M25 motorway, a beltway freeway around London planned by the National Department of Transport. The motorway is expected to divert through trips around the periphery of Greater London, leading to a total reduction of 3.5% of all vehicle miles within London. There is concern that the road could encourage the decentralization of commercial and manufacturing activity, diverting needed jobs from London.

6. Harrison, A.J., Study of the Economic Impact of a Major Motorway Investment: Lancashire-Yorkshire Motorway, M62, Report of the Fourth Round Table on Transport Economics: The Impact of Infrastructural Investment on Economic Development, European Conference of Ministers of Transport, Paris, 1969.

7. Hart, Douglas A., Strategic Planning in London, Pergamon Press, Oxford, England, 1976.

   This book presents a case study history of planning urban motorways (freeways) in London. It traces the development planning of three ringway revisions to the plans. Cost, demolition of considerable housing, and other community impacts generated tremendous public opposition to the plans; the inner ringroad was eliminated, and the outer two combined into one planned circumferential road.

8. Holmes, Edward H., Coordination of Urban Development and the Planning and Development of Transportation Facilities, U.S. Department of Transportation, Federal Highway Administration, Washington, D.C., 1974.

This report presents the result of an investigation of planning practice in cities in England, Scotland, Spain, Switzerland, France, Germany, Denmark, Sweden, Australia and Canada. The cities were selected because of especially effective technical, funding, legal, and citizen-participation programs.

9. Lassiere, A., Environmental Evaluation of Transport Plans at the Strategy Level, Planning and Transport Research and Computation Company, London, 1973.

10. LeBlanc-Bazou, et. al., Environment et Equipments Urbains, Centre de Recherche d'Urbanisme, Paris, 1971.

Theoretical discussion of the role of public facilities, transportation and open space at various scales of urban development. Beltways are specifically discussed in terms of the function at a regional scale in preserving open space while providing accessibility. Of limited relevance to American conditions, but a good summary of French theories about urban form.

11. Mackie, A.N., Environmental Effects of Bypassing Small Towns: Case Studies at Boughton, Dunkirk and Bridge, Transportation and Road Research Laboratory, Crowthorne, England, 1978.

12. McDonald, Thomas, Roads We Should Have, American Automobile Association Minutes of Annual Meeting, 1936.

Describes traffic conditions out of London and Paris and the national auto roads of Germany. Discusses the application of German motor highways to U.S., and advocates ring instead of bypass roads in highway planning.

13. Ostrowski, Waclaw, L'Urbanisme Contemporain, Centre de Recherche d'Urbanisme, Paris, 1970.

Extensive documentation on all facets of urbanization, mainly in Europe but also in the USA, USSR, India, Japan, and Brazil. Discussion of the role of regional transportation systems with illustrations, but no statistical analysis or detailed assessment of land use policies. Examples of beltways are presented, but the land use and urban development impacts are not analyzed.

APPENDIX F. METHODOLOGY

1. Berry, Brian J. L., (ed.), City Classification Handbook: Methods and Applications, Wiley-Interscience, New York, 1972.

   Contains 12 essays grouped into five sections as follows: methodological background, dimensions of variation and derivation of classes; uses of city classification in social and political research; alternative modes of classification and types of cities; strengths and weaknesses of classification procedures; and a final overview.

2. Bishop, A. Bruce, C.H. Oglesby, and Gene E. Willike, Socio-Economic and Community Factors in Planning Urban Freeways, Project on Engineering-Economic Planning of Stanford University, Stanford, California, 1969.

3. Bureau of the Census, U.S. Department of Commerce, Construction Statistics Data Finder, U.S. Goverment Printing Office, Washington, D.C., 1978.

4. Canty, Eugene T. and Thomas F. Bolab, Procedure for Estimating National Market and Total Socio-Economic Impacts of New Systems of Urban Transportation, Highway Research Record, No. 399, 1972, pp. 87-98.

5. Charles River Associates, Measurement of the Effects of Transportation Changes, Prepared for the Urban Mass Transportation Administration, Cambridge, Mass., 1972.

   Presents a review of transit and highway impact studies and a conceptual framework for evaluating the impacts of transportation changes. Specific literature is reviewed, research designs for impact analysis are proposed, data collection methods are described, and recommendations for further research are presented.

   Highway impact studies were most severely criticized because they lacked a theoretical foundation, focused mainly on corridor effects ignoring issues of transferability, assumed the validity of a "before-after" methodology, and did not adequately distinguish user benefits from indirect land use and development effects. The authors concluded that a before-after research design is inappropriate unless more than two time periods are included.

6. Charles River Associates, Policy Evaluation with Travel Behavior Models: Methodological Issues and Case Studies, U.S. Department of Transportation, Cambridge, Mass., 1979.

   This report presents applications of recent advances in travel demand model estimation to current policy issues and, based on these findings, makes recommendations for further improvements in travel behavior forecasting.

7. Christensen, Kathleen, Social Impacts of Land Development, The Urban Institute, Washington, D.C., 1976.

This report explores changes in the physical environment of a neighborhood, and how these changes may affect the neighborhood as a social environment. Discusses recreation patterns at public facilities, shopping opportunities, pedestrian mobility, etc. Tables and diagrams. Bibliography has references on case studies, data collection methodology, legal background, and general related reading.

8. Coombs, P.R.J., An Approach to an Assessment of the Effects of Policies Relating to Traffic Management Schemes and Land Use Plans in Urban Areas, with Particular Reference to "Environmental Areas", Department of Transport Technology, Loughborough University of Technology, Loughborough, Great Britain, 1973.

9. Curry, David A., and Dudley G. Anderson, Procedures for Estimating Highway User Costs, Air Pollution, and Noise Effects, National Cooperative Highway Research Program, Report 133, Highway Research Board, Washington, D.C., 1972.

This study develops procedures that can be used to select level of traffic service on the basis of user costs and related consequences of air and noise pollution. It is oriented to highway engineers, planners, and policymakers responsible for the planning and evaluation of highway programs.

10. Deacon, J.A., et. al., Urban Transportation and Land Use, University of Kentucky, Report for the U.S. Department of Transportation, Washington, D.C., 1976.

A minimally technical exploration of the complex relations among activity, movement, and land use. It identifies techniques for coordinated land and transportation development that support goals of increasing transportation efficiency, reducing motor vehicle use, etc. Subjects covered include urban form, car-pooling, travel disincentives, zoning, access design, noise, etc. Extensive bibliography.

11. Dickey, J.W., and R.A. Hall, Experiments with an Interactive Search Procedure for Changing Transportation to Guide Urban Growth, Civil Engineering Department, Virginia Polytechnic Institute and State University, Blacksburg, Va., 1971.

12. Economic Development Administration, Urban and Community Impact Analysis, U.S. Department of Commerce, Washington, D.C., 1977.

This report describes the "Capital Development and Investment Program (Local Public Works)," a program to make grants to States and localities for construction of and renovation of public works and facilities in order to stimulate employment and serve as a countercyclical stimulus. Chief issues addressed include population, employment, fiscal programs, CETA, etc.

13. Erickson, Paul A., George Camougis, and Edward J. Robbins., Highways and Ecology: Impact Assessment and Mitigation, New England Research, Inc., for Federal Highway Administration, 1978.

This book uses an ecosystem approach to impact assessments. The components and dynamics of terrestrial, aquatic and wetland ecosystems are described. Potential biological and ecological impacts of a highway project are also described. Extensive bibliography.

14. Faucett (Jack) Associates, Methodology for Relating Highway Investment to Regional Economic Activity: Interim Report, Silver Spring, Maryland, 1970.

15. Gamble Hays B., and Thomas B. Davinroy, Beneficial Effects Associated with Freeway Construction, Environmental, Social and Economic, National Cooperative Highway Research Program Report 193, Transportation Research Board, Washington, D.C., 1978.

Discusses the approach of the research, findings, and their application, and suggests avenues of further research. The study cites many different literature sources, and there are sections detailing technical aspects of benefits. Important negative impacts are pointed out. Extensive bibliography.

16. Gamble, Hays B., David C. Raphael, and Owen H. Sauerlender, The Impact of Interchange Development on the Economy of Clinton County, Institute for Research on Land and Water Resources, Pennsylvania State University, University Park, Penn., 1966.

17. Greenston, Peter and Carl Snead, Urban Institute, A Selected Review of Urban Economic Development: Observations, Issues, Strategies and Assessments, Economic Development Administration, National Technical Information Service, Springfield, Virginia, 1976.

Considers both regional inter-metropolitan and intrametropolitan trends. Summarizes current population and job movements, and relates these to federal policy options. Evaluates strategies to help central city economies and the influence of federal policies (circa 1976) on suburbanization and interregional growth. Specific attention is devoted to arguments for an "open suburbs" dispersal policy versus inner city redevelopment, etc.

18. Harris, Curtis C., Jr., Regional Economic Effects of Alternative Highway Systems, Ballinger Publishing Co., Cambridge, Mass., 1974.

19. Harris, Curtis C., Jr., et. al., Long Range Transportation Investment Planning: A Forecasting Approach for Assessing the Impact of Alternative Highway Systems on Regional Development, Highway Research Record, No. 458, pp. 13-20, 1973.

20. Isard, Walter, Methods of Regional Analysis, Massachusetts Institute of Technology Press, Cambridge, Mass., 1960.

A wide range of analytical techniques in regional science are described and evaluated.

21. Johnston, J., Economic Methods, Second Edition, McGraw-Hill, New York, 1972.

Develops the concepts of econometric methods. Highly mathematical and academically oriented.

22. Kain, John F., "The Journey-To-Work as a Determinant of Residential Location," Papers and Proceedings of the Regional Science Association, Vol. 9, pp 137-160, 1962.

The expected static equilibrium solution is compared with Detroit data on the distribution of households across a series of concentric zones. The model shows no major discrepancies with the observed distribution.

23. Keefer, Louis, Urban Travel Patterns for Airports, Shopping Centers, and Industrial Plants, National Cooperative Highway Research Program Report 24, Transportation Research Board, Washington, D.C., 1966

This research was initiated to determine the criteria or values which establish the travel patterns created by various major traffic generators. The initial project specified the study of airports, shopping centers and industrial areas in cities of more than 50,000 population. The nature of relationships between travel patterns and the various characteristics of traffic generators, the transportation network, and the contributory area are evaluated for these three types of land use. Contains annotated bibliography.

24. Keyes, Dale L., Land Development and the Natural Environment: Estimating Impacts, The Urban Institute, Washington, D.C., 1976.

Part of a series. Covers air quality, water quality, flooding, wildlife, vegetation, and noise. A thorough introduction, not very technical. References, no bibliography.

25. Leone, Robert A., "The Role of Data Availability in Intrametropolitan Workplace Location Studies," Annals of Economic and Social Measurement, pp. 171-182, January, 1972.

This paper first identifies the most glaring deficiencies of the data sets commonly used for location analysis; second, it enumerates a set of criteria for a sound data base; and third, it investigates the potential of a new data base, the Dun and Bradstreet DMI File.

26. Lisco, T.E. and M. Wachs, Social, Economic, and Environmental Impacts of Transportation Systems, Highway Research Board Special Report, No. 143, pp. 89-113, 1973.

27. Llewellyn, Lynn G., Social Impact Assessment: A Survey of Highway Planners, U.S. Fish and Wildlife Service, Washington, D.C., 1975.

28. Llewwllyn, Lynn, et. al., "The Role of Social Impact Assessment in Highway Planning," Environment and Behavior, pp. 285-306, 1975.

29. Lowry, Ira S., Seven Models of Urban Development: A Structural Comparison, The Rand Corporation, Santa Monica, Cal., 1967.

Shows how a number of quantitative models relate to each other and to the theory of urban land markets. Focuses on significance of variables included, and on coherence of models' formal structure. Not highly technical.

30. Manheim, Marvin, et. al., Transportation Decision-Making—A Guide to Social and Environmental Considerations, National Transportation Research Board, Washington, D.C., 1975.

Includes: evaluation and reporting, consideration of alternatives, area identification of impacts and affected interests.

31. Mason, Joseph B. and Charles T. Moore, "Commercial Site Selection at Interstate Interchanges," Traffic Quarterly, 1973, pp. 19-33.

32. Mehta, Rajendra K. and Frank L. Ventura, A Method of Predicting the Effect of Long Range Transportation Plans on Residential Land Use Activities, Warren, Mich., 1973.

33. Mohring, H.D. and M. Harwitz, Highway Benefits, Northwestern University Press, Evanston, Ill., 1962.

34. Muller, Thomas, Fiscal Impacts of Land Development, The Urban Institute, Washington, D.C., 1975.

Part of a series. Discusses topics such as public service demand, cities vs. suburbs, etc. A thorough introduction. Good bibliography. Non-technical approach.

35. Peskin, Robert L. and Joseph L. Shofer, The Impacts of Urban Transportation and Land Use Policies on Transportation Energy Consumption, U.S. Department of Transportation, Office of University Research, Washington, D.C., 1977.

This report explores relationships between energy consumption in urban passenger travel, land use, transportation system characteristics, and travel behavior. Findings are based on 112 experiments conducted with an integrated equilibrium transportation-land use simulation model.

36. Putman, Stephen H., "Urban Land Use and Transportation Models: A State-of the-Art Summary," Transportation Research Review, 1975, pp. 187-202.

37. Rodgers, Andrei, et. al., The Time Lag of Factors Influencing Land Development, Institute for Research in Social Science, University of North Carolina, Chapel Hill, 1963.

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59. U.S. Department of Transportation, Guidance Notebooks for the Environmental Assessment of Airports, U.S. Government Printing Office, Washington, D.C., 1978.

60. U.S. Department of Transportation, Federal Highway Administration, The Audible Landscape: A Manual for Highway Noise and Land Use, Washington, D.C., 1974.

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62. Voorhees, Alan M. and Associates, Inc., Guidelines to Reduce Energy Consumption Through Transportation Actions, U.S. Department of Transportation, Washington, D.C., May 1974.

63. Walton, L. Ellis, Jr., "The Interstate System. A Return on Investment Analysis: Its Implications for Land Economic Studies," Right of Way, 1970, p. 43.

64. Weiner, Paul, Environmental Factors in Transportation Planning, Lexington Books, Lexington, Mass., 1972.

65. Wendt, Paul F. and Michael A. Goldberg, "The Use of Land Development Simulation Models in Transportation Planning," Highway Research Record, No. 285, 1969, pp. 82-91.

APPENDIX G. DATA FOR THE COMPARATIVE STATISTICAL ANALYSIS

1. U.S. Department of Commerce, Bureau of the Census, County and City Data Book, 1977, 1972, 1968, 1963, Washington, D.C., 1978.

   Land Area, Population, Percent Black Population, Net Migration, Total Employment, Manufacturing Employment, Trade Employment, Per Capita Income, Annual Increase in Per Capita Income, Housing Units, Change in Housing Units, Occupied Housing Units, Percent Single Family New Units, Per Capita Property Tax, Government Highway Expenditure, Manufacturing Capital Expenditure, Percent Change in Value Added by Manufacture, Wholesale Employment, Ratail Trade Establishments, General Merchandise Establishments, Eating and Drinking Establishments, Total Retail Sales, Auto Dealer Sales, General Merchandise Sales, Apparel and Accessory Sales, Total Retail Employment, Selected Services Employment, Percent Government Employment.

2. _____, U.S. Census of Population, 1970, Washington, D.C., 1972.

   Table 190: Percent Suburban Residents Working in Central Business District; Percent Suburban Residents Working in central city, not in Central Business District; Percent Suburban Residents Working in Other SMSAs.

   Table 196: Percent Government Employment, SMSA, 1970.

3. _____, U.S. Census of Retail Trade, 1977, Washington, D.C., 1979.

   All above retail items, 1977.

4. _____, U.S. Census of Wholesale Trade, 1977, Washington, D.C., 1979.

5. _____, U.S. Census of Manufacturing, 1977, Washington, D.C., 1979.

6. U.S. Department of Commerce, Weather Bureau, Climatograph of the United States, No. 83, Washington, D.C., 1963.

   Degree-days (1931-1960 data).

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   Tables 2, 11: Owners Moving from Central City; Owners Moving from Outside the SMSA; Renters Moving from Central City; Renters Moving from Outside the SMSA; and information on above items for blacks.

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10. _____, Office of Policy Development and Research, Decentralizing Community Development, Washington, D.C., 1978.

11. U.S. Department of Transportation, Federal Highway Administration, Office of Highway Planning, National Functional System Mileage and Travel Summary from the 1976 National Highway Inventory and Performance Study, Washington, D.C., 1977.

Table IV: Freeway Miles; Freeway DVMT as Percent of Total VMT.

Table IV: Principal Arterial Miles/1,000 Persons; Daily VMT/1,000 persons.

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6. Duisin, Xenia W., Cost-Benefit and Cost-Analysis: Application to Public Transportation, A Bibliography, Council of Planning Librarians, Monticello, Ill., 1978.

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11. Hsu, Ann Yi-rong and James O. Wheeler, A Bibliography of Highway Impact Studies, 1966-1976, Council of Planning Librarians, Monticello, Ill., 1978.

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