Land Use-Transportation Literature Review
For the
I-5 Trade Corridor
Regional Land Use Committee

Submitted by:

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INTRODUCTION

Our focus in this literature review is to understand the land use impacts of transportation investments. This review, when coupled with Metroscope modeling results and stakeholder committee discussions, will support planning of desirable land use outcomes for the four-county Portland-Vancouver region from proposed capacity improvements in the I-5 corridor.

Metropolitan areas differ greatly in historical development patterns, geography, population mix, political traditions, and economic vitality, which may lead to significant differences in the specific outcome of a particular policy initiative or transportation investment project. Additionally it should be noted that land use patterns change very slowly compared to travel behavior. That is, changes to the built environment require more time to materialize than an individual's shift in travel schedules, routes, modes, and destinations. As a result, it is difficult to find conclusive evidence on land use impacts of transportation improvements. Thus; one often relies on the evidence of travel behavior change instead.

The pages that follow reflect current thinking and case study evidence of the effects of transportation investments on land use and the effectiveness of land use planning tools. The following section summarizes the major findings culled from the literature and case studies. In the remaining sections, these topics are given more explanation, and individual case study evidence is listed.

EXECUTIVE SUMMARY

The I-5 Trade Corridor Regional Land Use Committee is tasked with both understanding and recommending tools to manage the land use effects from proposed I-5 highway and transit investments. Three questions, relevant to the I-5 project land use impacts were posed during the literature review. The questions, answers, and implications for I-5, comprise the remainder of this section.

1. HOW DOES TRANSPORTATION INVESTMENT AFFECT HOUSEHOLD AND BUSINESS LOCATION DECISIONS?

1.1. Transportation has helped shaped modern US metropolitan areas.
1.2. Accessibility leads to development, with diminishing returns.
1.3. Accessibility can increase land values and densities.
1.4. Transportation is not the only influence on development.
1.5. Households reinvest travel time savings in longer trips and more travel.
1.6. Accessibility still matters in the new economy.

Summary: Transportation investment affects accessibility. Accessibility changes are reflected in travel behavior. Changes in travel behavior have the potential to alter land use.

Available land, lower land costs, and less congestion invite residents and business to the urban fringe. Recent employment growth in most major metropolitan areas has primarily occurred in dispersed suburban activity centers outside of central cities and downtowns. These centers are not-easily served by transit, reflecting the growing dispersion of jobs and housing.

Many businesses continue to value proximity to other businesses ("face-time") and thus tend to locate in concentrated nodes. In less urbanized areas, such development concentrations typically

follow a life-cycle development process, beginning with “urban villages” currently located near major freeway interchanges.

Residential development has tended to develop in a more decentralized fashion than employment, locating 2-3 times farther from work than necessary. However, increased land values motivate higher density land uses, such as compact housing and mixed land uses. Higher densities are naturally supported near transit stations, as confirmed by increased residential land values. Higher density nodes can support affordable housing. Excessive housing costs can increase wages and other business costs. Improved access to suburban job centers can avert a jobs-housing mismatch for low income workers. Local comprehensive plans are a "chief ingredient" in controlling and mitigating land use impacts.

Stable average commuting times in the last 20 years reflect the trend for jobs and housing to co-locate in suburban developments. Suburban commute times, however, have lengthened with the largest cities having the longest commutes. Higher densities and mixed land use development reduce trip lengths. The ability to reach further locations in a shorter time may disperse residential locations and result in longer shopping and services trips, as local businesses are bypassed for competitors made more accessible.

The accessibility provided by new fixed rail transit, seen as a more permanent public commitment to the community than bus service, may be converted into increased residential land values. Worker "quality of life factors," important to businesses such as high-tech, include commuting options and congestion levels. Transit is seen as a favorable commute option and allows access to a larger labor pool. Factors other than transportation will play an equally significant role in employment location decisions, including market conditions, existing economic activity patterns, the availability of infrastructure-ready land, development costs and incentives (e.g., targeted land development plans and minimum density requirements), pro-business attitudes, and topography. Transportation costs for business have declined for decades.

As a region grows, any one transportation investment has less impact on accessibility and its resulting land use changes. Those places at the edge of urban areas are often affected most, with jobs following households, particularly affluent and educated households, to these areas.

2. HOW DOES TRANSPORTATION INVESTMENT AFFECT TRAVEL BEHAVIOR

2.1. Induced demand often exceeds traffic forecasts
2.2. Local conditions affect the level of induced demand.
2.3. Truck responses to congestion are limited; they are more time-sensitive.

Summary: Travel responses to highway capacity improvements can affect the land use impacts discussed in the previous question. Expected travel responses include: (A) shifts in route, mode, and time of travel; (B) shifts in destinations; (C) new trips generated by new development; and (D) new trips induced by improved accessibility. Decreases in capacity can suppress demand. New trips "induced" by changes in land uses or improved accessibility are most difficult to forecast.

The literature overwhelmingly suggests that induced travel is likely to increase facility demand over forecast levels, with up to half of long-term effects due to land use changes. The higher demand can often reduce or eliminate the facility's planned congestion relief, curtailing expected delay and air quality benefits. Even with little congestion relief, however, traffic widening

projects provide benefits in reducing the duration of the peak period, carrying more vehicles per hour, and supporting access to a larger choice of home, work, and retail/service locations.

Despite inconsistencies among studies, induced demand is generally projected to increase 0-10% for each 10% increase in road/lane miles, and 5% for every 10% travel time reduction. Local conditions, such as existing levels of congestion, traveler's value-of-time, and potential travel cost savings, affect the level of induced demand.

Goods movement is more sensitive than the general public to congestion and travel reliability. Businesses cannot forego travel, and shifts to other routes, modes, or times may not be possible. Thus they often bear the costs of congestion. However, transport costs have historically been a small cost component for most businesses.

3. HOW CAN PUBLICE POLICY SHAPE THE RESULTING GROWTH?

3.1. Land use planning methods and policies affect development patterns and travel behavior.
3.2. Metropolitan political systems affect land use outcomes.

Summary: The land use effects of transportation investment is often small compared to the effect of local land use plans, policies and political structures. Indeed, recent evidence in Oregon found that road widening in urban fringe cities posed little change to local land use plans in place prior to the transport investment. Effective policies are able to control growth resulting from transport investment, effectively maintaining planned development despite development pressures brought by the transport improvement.

Governments harness a host of available land use planning and policy tools in order to develop the type of communities desired. Tools include: (A) managing long term growth through long term plans (e.g., concurrency, targeted land development, phased transport and focused public service investments); (B) influencing site plans as development occurs (e.g., traditional neighborhood design, minimum density requirements); (C) preserving rural/open space from development (e.g., urban growth boundaries, public land acquisition, urban reserve zoning); (D) transportation design standards to effectively integrate land uses (e.g., access management); (E) demand management to preserve available transport capacity for its highest use (e.g., parking fees, HOV or truck-only lanes); and (F) cost recovery of development-induced public infrastructure investments (e.g., impact fees, taxation). Continued regional cooperation, fostering a strong business climate, and working with neighborhoods will also be important to corridor development.

The remainder of this document discusses these issues and the supporting case studies in more depth.

1. HOW DOES TRANSPORTATION INVESTMENT AFFECT HOUSEHOLD AND BUSINESS LOCATION DECISIONS?

1.1. Transportation has helped shape modern US metropolitan areas.

In the past 20-30 years, the growth in the US economy, and the accompanying growth in standards of living, have created a pattern of decentralization to suburban sub-centers, less dense than the traditional cores in major US urban areas. This shift has been fueled by structural changes in the nation's economy (the growth of the service sector), and by transportation investments, particularly highways, and it has been supported, in some cases, by transit investments. During the 1980s, suburban employment centers largely clustered around major freeway corridors, in which accessibility advantages attracted business. Indeed, suburbs once viewed as residential extensions of the city are increasingly seen as maturing economies in their own right. Among the major US cities, Dallas, Los Angeles, and San Francisco have 10-20 suburban centers. Such nodes have often evolved from bedroom communities at freeway crossroads to high-rise high-tech office centers. Transit can support such growth in a more concentrated nodal fashion.

Case Study Evidence

- An NCHRP primer on transportation and economic development characterized suburban growth into ***4 progressive stages leading to the development of "suburban downtowns."*** The development stages are: bedroom community, independence, catalytic growth, and high rise/high tech. [1] Another study examined 57 (primarily office-based) suburban centers through the US, classified them as office parks, office and convention centers, large-scale mixed-use developments, moderate scale mixed-use developments, sub-cities, and large-scale office growth corridors.[2] Another article notes the life cycle of urban villages that have emerged around shopping malls at the intersection of major highways and originally contained little office space. Between 1980-1985 such areas attracted the bulk of office space, often with high-rise buildings, and a newfound ability to attract major finance and regional corporate headquarters, historically drawn to the CBD. Likewise, the downtown core is decentralizing and becoming just another urban village. [3]
- A comprehensive study of employment trends for the top MSAs between 1969 and 1994 identified a ***shift to service sector employment with growth occurring outside central cities.*** Isolating the expanding sunbelt cities (Dallas, Denver, Houston, Portland, Sacramento, San Francisco, Seattle), the study found that the service industry growth (4.5%) was nearly double that of other sectors, with strong showing by Finance, Insurance, and Real Estate (FIRE) (2.8%), Retail (2.8%) Wholesale (2.5%), and construction (2.5%), and negligible manufacturing growth (0.3%). The growth of Services, FIRE, and retail was concentrated outside the central city after 1988. There was an absolute decline in central city jobs for manufacturing, wholesale, transportation, and vehicles.[4]
- A study of employment sub-centers ***in Los Angeles identified one-third of the region's employment within 32 sub-centers*** (10.7M pop, 4.65M jobs in 1980). Within the centers, a cluster analysis revealed 5 general categories: Specialized manufacturing (7 centers), mixed industrial (9), mixed service (11), specialized entertainment (2), and specialized service (3).[5]

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1 Hartshorn, T., Muller, P., "The Suburban Downtown and Urban Economic Development Today." In *Sources of Metropolitan Growth*, Mills, E., McDonald, eds., Center for Urban Policy Research, Rutgers University. (1986)

2 Cervero, R., "*America's Suburban Centers: The Land Use-Transportation Link*, Boston. (1989)

3 Leinberger, C., Lockwood, C., "How Business is Reshaping America," *Atlantic Monthly*. (Oct 1986)

4 Gordon, P., Richardson, H., Gang.Y., Metro and Non-metro Employment Trends in the US: Recent Evidence and Implications, *Urban Studies*, 35:7, pp.1037-1057. (1998)

5 Giuliano, G.,.Small, K., "Subcenters in the Los Angeles region," *Regional Science and Urban Economics*, Vol. 5, pp. 305-312. (1991)

- A recent study of ***San Francisco Bay Area*** between 1980 and 1990, characterized the area's significant employment decentralization and development of ***22 suburban employment centers***. These centers were generally split into four groups, downtown San Francisco, East Bay Core, Silicon Valley/San Jose, and Suburban Centers. The largest 1980s employment growth rates were in the suburban centers (64%, 45% for Silicon Valley), with only a fraction of that growth rate (9-16%) occurring in traditional urban core areas (downtown SF and East Bay).[6]
- A study of San Francisco BART rail transit development impacts after 20 years (1970-1990) clearly indicated that ***regional growth was more pronounced in non-BART service areas, despite BART's role in anchoring downtown core areas*** (San Francisco and Oakland). However, BART stations attracted businesses employing professional, technical, and executive workers (e.g. FIRE and consumer services) at a rate 15-20% higher than other locations. BART played a role in the emergence of 3 suburban centers as important nodes of commercial and office development (Walnut Creek office concentration, Pleasant Hill apartments, and Fremont mixed use). Rent premiums were identified in apartments near BART. The study concludes that ***BART, rather than create growth, has acted to redistribute growth.***[7]
- A study of employment within the Dallas-Fort Worth region identified 19 employment centers containing 69% of the CMSA employment (5.0M pop, 1.5M jobs in 1985). The study concluded that accessibility often redistributes economic growth within a region and shapes urban form. Additionally, it found that a metropolitan area with numerous specialized centers has an unequivocal advantage over one that does not.[6]
- A recent summary of highway investment effects on metropolitan development concluded that although metropolitan growth may be driven by other factors, highways have the potential to channel such growth to some areas over others. It identifies highway funding as the federal government's "hidden" urban policy program. [8]

Urban Development Problems:

- Documentation supporting the development of a 20-year land use and transportation vision for the San Francisco Bay Area noted that a ***chief economic issue faced by the region is the shortage of housing, particularly affordable housing.*** The median home price exceeds the median income by up to 80% in San Francisco and almost 50% in San Jose. ***Housing issues have impacted the ability to retain service workers***, such as child care workers, retail salespeople, firefighters, elementary school teachers, police patrol officers, and registered nurses, all making less than the median income for a 3-person household. As a result, workers struggle to find housing they can afford and ***businesses face upward pressures on wage levels and often have difficulties recruiting employees, escalating the cost of doing business in the area***. Workers have moved to distant parts of the Bay Area and into the Central Valley in order to find affordable homes, leading to long-distance commuting, traffic congestion, and air pollution.[9]
- A study of new suburban employment centers in the San Francisco Bay area found that emerging centers are less well served by transit and little housing, contributing to longer commute distances. Suburban centers experienced a 20-26% increase in commute distance compared to a regional increase of only 12% when urban areas are included. Likewise, commuting times increased by 14-24%, with only 5% increase region-wide. The share of mass transit commuters fell from 58% to under 3% for those relocated from downtown San Francisco. [6]

  The San Francisco study also identified increased commuting from land use development patterns where residents locate in far-flung communities, separated from a primary city. Such development was found to result in a 23% increase in average commuting VMT, with 80% attributable to longer home-work distances.
- Employer movement to the urban fringe has been linked to limiting job opportunities for inner city residents. [10] The literature indicates this "spatial mismatch," plays a role in the demand for Welfare to work programs.

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6 Cervero, R., Landis, J., "Suburbanization of jobs and the journey to Work: A Submarket Analysis of Commuting in the San Francisco Bay Area," *Journal of Advanced Transportation* 26:3. (1992) and Cervero, R., Wu, K, "Sub-Centring and Commuting: Evidence from the San Francisco Bay Area, 1980-90," *Urban Studies*, 35:7, pp. 1059-1076 (1998)

7 Cervero, R., "BART @ 20: Land Use and Development Impacts," Institute of Urban and Regional Development, University of California at Berkeley. (July 1995)

8 Boarnet, M., Haughwout, A., "Do Highways Matter? Evidence and Policy Implications of Highways' Influence on Metropolitan Development," Brookings Institution Center on Urban and Metropolitan Policy. (August 2000)

9 Association of Bay Area Governments (ABAG) et al, "Briefing Book for Public Workshop Participants and Other Bay Area Residents," Smart Growth Strategy, Regional Livability Footprint Project. (August 2001)

10 Ihlanfeldt, K., "The Importance of the Central City to the Regional and National Economy: A Review of the Arguments and Empirical Evidence," *Cityscape* 1:125-150. (1995).

1.2. Accessibility leads to development, with diminishing returns.

Transportation investment has long been associated with economic growth and development. Economic growth is drawn to areas with relatively low cost developable land, made more accessible by transportation improvements. Historical examples include nineteenth century commuter rail, and canal and transcontinental railroad reductions in business costs, spurring significant economic expansion.

More recently, accessibility has increased urbanization of areas at the outer edge of primary cities and, to a lesser extent, fueled the development of "interchange villages" in rural areas. As jobs and employment both decentralize, they reinforce one another.

Interstate highways have given suburban locations the level of accessibility previously only found in central business districts (CBDs). Improved accessibility on the urban fringe can push some businesses and housing outward, decentralizing growth and taking advantage of new (temporarily) less congested transportation links. In contrast, congestion gives firms and residents an incentive to locate in a more compact fashion. Depending on the circumstances, this may lead to the creation of strong downtowns and/or stronger suburban centers.

Increasingly, modern-day urban Interstate Highway investment are serving both intra-metropolitan travel needs and national commerce.

Contrary to the historical view of transport investment as an economic generator, the most recent evidence suggests that although transportation enables and may accelerate growth; it does not in itself generate long-term economic activity. In areas with limited existing accessibility and/or untapped potential, investment can have large impacts. Conversely, in areas that already enjoy good accessibility (e.g. well developed transport infrastructure) and/or more mature economic development, new investments have less impact.

Rather than opening up areas to new development, most transportation investment projects today provide only small accessibility enhancements, in the context of the larger regional transportation system. Some projects, such as transit improvements or high occupancy vehicle (HOV) lanes, have even smaller effects as they improve travel times for only a small share of the overall travel market.

Case Study Evidence

Redistribution

- A 1991 NCHRP report downplays the overall regional economic benefit of transport investment. It quotes: "While studies often report [a] large number of jobs either directly or indirectly associated with transportation facilities, more in-depth investigations find that ***virtually all employment associated with expansions of the transportation system in mature economies would be absorbed elsewhere in the labor market if the investment were not to take place***. Only where a regional economy displays long-term structural unemployment can regional net gains in employment and income stem from transportation policies and projects. Even than, the gains are typically small."[11]
- Analyses of 1964-1971 land values surrounding a Philadelphia commuter rail line indicate that much of the increase in property values was offset by corresponding decrease in values in other corridors.[12]
- A study of the Ozarks region of Arkansas found limited land use changes resulting from highway investment. The study concluded that ***the function***

[11] Lewis, "Primer on Transportation and Economic Development," NCHRP. (1991)

[12] Boyce, D. E. and W. B. Allen, *Impact of Rapid Transit on Suburban Residential Development: Analysis of the Philadelphia-Lindenwold High-Speed Line*. Philadelphia, University of Pennsylvania (1973).

of highways is to make development possible (e.g., eliminating regional supply constraints) rather than to act as a stimulant to growth.[13]

- A recent review of highway impacts on urban areas found that "the first link in a metropolitan highway system is likely to bring large improvement in transportation access and thus…large increases in land prices near the project. As more highways are built, and the metropolitan highway network matures, the incremental effect on accessibility from new or improved highways decreases thus accounting for a smaller change..." Thus, as highway systems mature, highway benefits have become increasingly local. The study also notes: "that the land use effects (near the project) are likely at the expense of losses elsewhere."[8]

Urban Areas:

- A matching study of US counties during the period 1963-1984 found that the ***primary beneficiaries of the interstate investment were counties in close proximity to large cities or having some degree of prior urbanization.*** Rural counties and those not near interstates exhibited few positive effects from highway investment, with freeway access enabling competition for local services. Small urban areas (city of 25,000 population) experienced an increase in earnings (+50%), as well as retail (+90%) and government (+120%) jobs over matched non-highway counties, accompanied by a statistically significant decline in residents (-6%). Large city spillover counties (40-60 miles from cities over 100,000 population, depending on city size), experienced similar earnings (+75%) and positive residential growth (15%) but lower retail and government growth. Spillover county growth was indicative of decentralization to the urban fringes. ***Rural counties with interstates grew but were susceptible to competition for local goods and services from other locations along the freeway***.[14]
- A study of 1957-1982 highway expenditures in Minnesota found that ***highway investment had the largest long-term employment effects in small cities or urban fringe areas***. A $1 million expenditure in the highway system was shown to generate 108 long-term jobs in counties that were either on the edge of urbanized metro areas or containing small cities (25,000 population). Half that number of jobs (52) was created in urban counties, while only 5 long-term jobs were created in rural counties.[15]
- A study of 1980s highway construction in Northern New Jersey near New York City concluded that ***job followed prior population growth into the outer suburbs*** and that the dispersion of new jobs and housing, particularly housing, led to high traffic volumes on highways. Between 1970-1987,the 13 county area increased 31% in employment and only 1% in population. Highway traffic increased 30-40% over this period, with little increase in lane-miles.[16]
- A separate study of 1980-1988 development in northern New Jersey showed that the ***rapid growth during this period was distributed to more affluent areas with better highway access***.[17]
- ***A study of US interstate highways*** impact on metropolitan growth in the 1970s ***found that people and jobs (especially manufacturing) moved to counties with more intense interstate highway networks***. Counties with double the interstate mile density had a 6 % increase in employment, with population increasing by 2.8%. This effect declined with distance from the cities.[18]

Non-Urbanized Areas:

- A study of non-metropolitan interstate highways interchanges (previously farming/rural areas) in Kentucky documented how ***10% of the studied interchanges became "interchange villages" functioning as central places within their regions***, while other locations had little effect. The "villages" underwent multiple waves of development including an initial activity phase during and immediately after construction, a mid-level development phase focused on supporting the transport function (e.g.,

[13] Kuehn, J.A. and J. G. West, "Highways and Regional Development," *Growth and Change*, pp. 23-28. (July 1971)

[14] Rephann, T., and A. Isserman, "New Highways as Economic Development Tools: An Evaluation Using Quasi-Experimental Matching Methods." *Journal of Regional Science*, Vol. 24 pp. 723-751. (1994)

[15] Stephanedes, Y., and Eagle, D., "Highway Impacts on Regional Employment." *Journal of Advanced Transportation*, Vol. 21, No. 1, pp. 67-79. (1987)

[16] Wolpert, J., "Regional Economic Growth and Highway Congestion," University Transportation Research Center, City College, NY. (1990)

[17] Boarnet, M. G., "An Empirical Model of Intrametropolitan Population and Employment Growth." *Papers in Regional Science: Journal of the RSAI*, Vol. 73 No. 2, pp. 135-152. (1994)

[18] Carlin, G., Mills, E., "The Determinants of County Growth." *Journal of Regional Science*. 27:1. pp. 29-53 (1987)

motels, gas stations), and ultimately, development of large-scale regional facilities. In the 6 identified "villages", the number of structures increased 4-5 fold over 10-15 years.[19]

- In a study of 1960s population growth in non-metropolitan areas of Pennsylvania, significantly higher growth rates were noted near highway interchanges within 25 miles of a primary city. ***Townships that were closer to a highway interchange grew at an average rate of 1.05% per year, compared to 0.60% for a non-highway impacted group.*** Low population density, an indicator of limited prior urbanization, was also a significant indicator of population growth. The effect of highway access on rural/non-metro areas was shown to atrophy with increasing distance from nearby metro area, with ***the strongest relationship in places within a 15-25 radius of a primary city, and no discernable effect beyond 25 miles***.[20]

[19] Moon, H. E. Jr., "Interstate Highway Interchanges as Instigators on Nonmetropolitan Development." *Transportation Research Record, 1125,* pp. 8-14. (1987)

[20] Humphrey, C., Sell, R., "The Impact of Controller Access Highways on Population Growth in Pennsylvania Nonmetropolitan Communities, 1940-1970," *Rural Sociology*, 40:3. (Fall 1975)

1.3. Accessibility can increase land values and densities.

Economic growth is drawn to areas with relatively low-cost developable land, made more accessible by transportation improvements. Increased accessibility, particularly to undeveloped parcels, can generate higher land values. Rail transit is seen as a permanent investment in a community, and accrues higher land valuations than more flexible bus service. Proximity to rail transit is associated with increased residential land values in metropolitan areas where transit has historically played a major role. Impact on commercial property values is less conclusive. Increased accessibility and land values often prompt higher land densities, including compact housing developments as well as the demand for a variety of activities in a given area, including multi-family housing near transit stations.

Case Study Evidence:

- ***A state of Washington study found property values increased by 12-15% for residents and 17% for commercial and industrial properties near highway interchanges.***[21]
- In the SF Bay area, ***BART station impacts, though uneven, exhibit a tendency towards multi-family housing near stations, some with residential rent premiums.*** Office buildings near BART stations did not command a rent premium, although those in Atlanta and Washington DC did show a slight premium for transit accessibility. The study also found increased employment growth at downtown San Francisco stations.[7]
- A review of over 19 recent studies in 10 major US regions found ***strong evidence of increased residential and commercial land values with rail transit investments***. Homes in communities with rail transit sold at a 6-8% premium per square-foot. Prices rose with increased distance from line but fell with distance from the station. Land capitalization relies on reliable, frequent and speedy service to a large market area. Evidence suggests that rapid and commuter rail systems have a greater impact on property values than light rail transit (LRT), due to their larger "sphere of influence" (e.g., higher speeds and increased regional access). Home price premiums decline by $32-2300 with each additional 100 ft distance from the station. The highest values were found near New York and San Francisco rapid rail stations with light rail transit (LRT) typically declining $80 or less per 100 feet. Similarly, rent premiums declined by 0.5% per 100 ft. Commercial effects, more difficult to quantify, were found to be influenced by the level of rail accessibility improvement, the relative attractiveness of the station area, and the overall health of the regional real estate market. Commercial rates found more variation, with negligible to $30 premiums per square foot within 0.5 miles of the station, with premiums decreasing by up to $2 with each 100-foot move away from the station. Property values effects, particularly with commercial uses, tend to be highly localized around the rail stations.[22]

[21] Palmquist, R, "Impact of Highway Improvement on Property Values in Washington State," *Transportation Research Record* No. 887. (1982)

[22] Parsons Brinckerhoff, "The Effect of Rail Transit on Property Values: A Summary of Studies," NEORail II Project, Cleveland, OH. (2001)

1.4. Transportation is not the only influence on development

The consensus in the literature is that transportation is a necessary but not sufficient condition for economic growth. Other local development factors must also be present to generate land use effects including available developable land (most growth is in the form of new construction), public policy favorable to development, and accelerated economic growth.

Case Study Evidence:

- ***In an Oregon*** review of development following highway widening near 6 fringe cities (primarily inside urban growth boundary), highway widening (2-3 new general purpose lanes) did not cause any obvious changes in the type of development. In 2 cases the investment may have fueled an increased rate of development, where strong economies and other factors (e.g., public infrastructure) were present. ***The study concluded that highway widening is unlikely to change what gets developed but will likely facilitate whatever development is already allowed, contributing largely to the rate of land use change. Local comprehensive plans were cited as the "chief ingredient" in controlling or mitigating the potential for future land use and economic impacts as a result of the highway widening projects***.[23]
- A comprehensive British study of roadway investment and travel behavior found that although road building has historically been felt necessary for urban growth, more recent evidence suggests that other local circumstances are more important. The study concluded ***"any contribution to the sustainable rate of economic growth of a mature economy, with well-developed transport systems, is likely to be modest."***[24]
- Local market conditions can obviate local policy efforts. For example the lack of development around stations on the Los Angeles Blue Metrolink Line reflects the line's location within a declining industrial area, and limited station access. Efforts to promote development around the stations have been unsuccessful.[25]

[23] ECONorthwest, Portland State University, "A Guidebook for Evaluating the Indirect Land Use and Growth Impacts of Highway Improvements," SPR Project 327, Oregon DOT. (April 2001)

[24] Wood, D.A., The Standing Advisory Committee on Trunk Road Assessment, The Department of Transportation, United Kingdom "Trunk roads and the generation of traffic," (1994)

[25] Loukaitou-Sideris, A., Banerjee, "There's No There There or Why Neighborhoods Don't Readily Develop Near Light Rail Transit Stations, "University of California Transportation Center. (1994)

1.5. Households reinvest travel time savings in longer trips and more travel.

Household location choice is influenced by many factors including: housing costs, access to jobs, access to goods and services, type of community, amenities/quality of life, public services/schools and property tax rates. The more numerous non-work trips for personal, family, civic, education, and recreation, may prove to be equally as significant as the work trip in housing location choice, especially for multiple worker households. Evidence suggests that households do not locate so as to *minimize* their travel distance from work; rather, they tend to keep their overall travel time within a certain amount, Despite differences in travel conditions and opportunities across US cities over the past 20-year, people spend the same amount of time per day, on average, in travel. The stability in commuting travel times suggests that transport accessibility improvements will allow households to locate further away from jobs, and that that any travel time savings may be used for more travel. (In the Vancouver-Portland region it may lead to household locations in outlying cities, rather than in the "rural sprawl" that typifies most other metropolitan areas.) The development shift to the suburbs in the past few decades initially reduced commute travel times as housing and jobs co-located along previously uncongested freeways. However, the increased traffic congestion of suburban areas has led to larger increases of late in suburban commute times.

Case Study Evidence:

- Research indicates ***that the average household lives two to three times farther from work than*** the spatial structure implies ***they must***.[26]
- A 20-year review of commuting patterns in metropolitan Washington DC found that commuting times remained stable at 32.5 minutes in 1968 and 1988 (and match closely the 1957 value of 33.5 minutes). However, average trip speeds increased by over 20% in the 20-year period, implying increased trip distances.[27]
- ***Commute travel times according to the US Census have increased on average by only 40 seconds from 21.7 to 22.3 minutes in 1980 and 1990***, despite suburban growth. [28] Conversely, the commute length increased 36.5% from 1983 to 1995.[29]
- Between 1980 and 1990 suburban commute times increased by 14%, while central city residents increased by only 5-7%.[30]
- ***Neighborhoods containing a mix of land uses have been shown to reduce travel.*** Residents of 3 mixed land use neighborhoods (Queen Anne, Wallingford, Kirkland) in 1992 Seattle traveled 28% fewer miles than adjacent areas and up to 120% fewer miles than suburban areas, for all socioeconomic categories. The daily travel time budget of 90 minutes (including walking) was the same across areas.[31]
- A comparison of the largest 20 US metro areas concluded that ***dense cities have much longer automobile commuting times than dispersed cities***. The conclusion was that decentralized cities co-locate housing and jobs to reduce commutes, shifting demand to use the available capacity of less-congested roads.[32]
- A recent testimony to the US Congress noted: "If congestion gets bad enough, more ***people will react by relocating their homes closer to their jobs or vice-versa, or by moving to smaller metropolitan areas.***"

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[26] Giuliano, G. and K. Small, "Is the Journey to Work Explained by Urban Structure?" *Urban Studies*, Vol. 30, No. 9, pp. 1485-1500. (1993)

[27] Levinson, Kumar, A., "The rational Locator: Why Travel Times Have Remained Stable," *Journal of the American Planning Association*. (Summer 1994)

[28] Pisarski, A., "Transportation Investment and Metropolitan Economic Development – A Reconnaissance of Research Availability and Requirements." (October 1990)

[29] FHWA data per Federal Transit Administration, "The Costs of Sprawl—Revisited," TCRP Report 39. (1998)

[30] Pisarski, A., "Travel Behavior Issues in the 90's: 1990 Nationwide Personal Transportation Survey," Report FHWA-PL-93-012 ,HS-042 089 (1992)

[31] McCormack, E., Rutherford, GS, Wilkinson, M, "The travel Impacts of Mixed Land Use Neighborhoods in Seattle," Transportation Research Board Annual Meeting (2001)

[32] Gordon, P., H. W. Richardson, and M. Jun, "The Commuting Paradox: Evidence from the Top Twenty." *Journal of the American Planning Association* 57:4 pp. 416-420. (1991)

- A recent study found that ***some of the US metro regions with the worst traffic congestion also have the largest portion of their workforce finding a way out by working at home or using alternate modes***. Successful multi-modal cities include San Francisco, Washington DC, Chicago, and Boston, all with over 23% using non-auto modes. In contrast few non-highway options are currently tapped (7-13% non-auto) in the highly congested cities of Los Angeles, Las Vegas, and Detroit. [33]

[33] Surface Transportation Policy Project (STPP), "Easing the Burden: A Companion Analysis of the Texas Transportation Institute's Congestion Study," (2001)

1.6. Accessibility still matters in the new economy.

Business locates to maximize profit. But for most industries, the cost of highway transportation is small compared to labor, capital, and other input costs. (One notable exception is low-value products (e.g., wheat, wood, scrap metal) where transportation costs are significant.) In the new global economy, even as businesses may reinvest their transportation cost savings, thus expanding their employment and markets, their most important "inputs" are the skills and dedication of their workers. So, both new firms and older, business giants seek locations that will help them attract and retain their skilled employees. Such attributes include good schools (for worker retraining as well as for their children), commuting options such as rail transit, low crime rates, and satisfactory health care.

Transportation increasingly functions as a quality-of-life amenity. Transportation allows a company to increase the "real income" of their employees (lower commuting costs). In fact, constant chronic congestion may push residents to relocate locally or to other regions with reduced congestion and/or better quality-of-life. Firms are increasingly leading and/or following workers to these more desirable locations. The growing office and service industry is more responsive to livability or quality-of-life factors than other industries, and typically more flexible and mobile in their location choice.

New economy firms value air transportation, for the shipments of high-value goods and access to an every expanding global market and business network. Large firms tend to need access to a wider labor pool, while branch offices need access to new customer base and the firm headquarters. Face-to-face contact remains important to many industries and supports high employment concentrations.

Case Study Evidence

Inter-Region Competition

- During the recent relocation decision of Boeing headquarters (500 employees) from Seattle to Chicago, Boeing stated that the company was seeking a culturally diverse city with ready access to global markets, a strong pro-business environment, and easy access to Boeing operations and customers.[34]
- A nationwide survey of the location decisions of 739 new manufacturing plants found that key location criteria include access to markets and skilled labor drawn by quality of life amenities. [35]

Location Decisions

- The importance of location factors varies by industry. Proximity to managerial labor and professional labor was statistically significant determinant of office-location choice for new firms with high levels of such workers (engineering, architectural, accounting, auditing), but not for other firms. Real estate firms that value access to non-labor inputs (e.g., available properties to view) were found to value office locations with access to expressways. Health and legal offices chose locations with high concentrations of these industries. Government and nonprofit organizations have less dependence on profit maximization actions and have historically chosen central city or clustered locations. [36]
- Wage rates vary with differences in commuting costs and other amenities. Transportation accounts for 15 to 20% of a household's net income, and is the second largest category of consumer spending after housing. Businesses provide employee programs to account for congestion effects (e.g., shorter work days, telecommuting, transportation assistance/trip reduction programs).[37]

[34] Richman, D., "Other Cities Woo Boeing with Incentives," Seattle Post-Intelligencer. (March 23, 2001)

[35] Calzonetti, F., Walker, F., "Factors Affecting Industrial Location Decisions: A Survey Approach, Industry Location and Public Policy." (1991)

[36] Clapp, J., Dynamics of Office Markets: Empirical Findings and Research Issues. *AREUEA Monograph Series*, No. 1, Washington, DC, The Urban Institute Press (1993).

[37] Power, T., "The Economic Value of the Quality of Life," Boulder Co, Westview Press. (1980)

- A recent review of highway investment impacts on urban areas noted that transportation cost reductions can help some industries (especially industries that already operate efficiently at a relatively large scale) by opening up new markets and reducing costs. However, the market for other businesses (especially high cost producers in small markets) can erode as lower transport costs eliminate the barriers that protected them from outside competition.[8]

Specific industry sectors

- Quality of Life (QOL) factors were ranked at least as important as accessibility in the location decision of headquarters, manufacturing, and R&D firms in a 1988 Site Selection survey. For **headquarters** and **manufacturing** firms, the primary criteria included the location's physical environment attractiveness (ranked 2nd), the quality of primary/secondary education, recreational amenities, and health care. Although access to a major airport was the top criteria, the overall transportation system ranked 3rd. The pattern was more pronounced for **R&D** firms, where only airport transportation (ranked 3rd) made the top 5 criteria, with nearby secondary education topping the list and two-career family economic opportunities (tied for 3rd) weighing in. [38]
- A study of 13 counties in Northern NJ in NYC CMSA, found residential amenities highly important in the location decisions of **high-tech** firms (Standard Industry Code 87). The availability of ***local rush-hour train service was one of several favorable attributes***.[39]
- In a survey of 691 **high-tech** company executives, the availability of technical labor and cost of labor were major considerations, followed by proximity to a university system and low taxes, and consideration of community attributes. Raw materials, energy, climate, and goods transport were not highly rated. [40]
- Study of **clerical** employment in major urban centers concluded that locations for routine work tends toward places with lower rents, lower taxes, and greater availability of space, such as the suburbs. In contrast, other office employees (e.g., administrators, managers, professional workers) still depend on face-to-face contacts available, more readily available in the central city. [41]
- Quality of life factors are increasingly a part of even old economy manufacturing firms' location decisions. In a survey of the local decision of 739 new **manufacturing** plants (since 1978), access to markets and skilled labor (especially for single-plant firms) were predominant, along with land costs/availability, taxes, personal reasons (primarily for single-plant firms), and education (primarily for branch plants). Wages, and livability factors, access to skilled workers (single-plant) were also important. Union labor factors were attributed more to branch plants with market factors more important to single plan establishments. [35]

[38] Lyne, J., "Quality of Life Factors Dominate Many Facility Location Decisions," Site Selection Handbook. (August 1988)

[39] Gottlieb, P., "Residential Amenities, Firm Location, and Economic Development" *Urban Studies* (1995)

[40] Calzonetti, R, Walker, R., "Factors Affecting Industrial Location Decisions: A Survey Approach," in Industrial Location and Public Policy, Herzog and Schlottman eds. Knoxville, TN, University of Tennessee Press. (1991)

[41] Daniels, P., "Transport Changes Generated by Decentralized Office," *Regional Studies*, Vol. 6, pp.273-289. (1972)

2. HOW DOES TRANSPORTATION INVESTMENT AFFECT TRAVEL BEHAVIOR?

Transportation capacity improvements increase travel by changing travel costs (time savings). Increasing evidence has suggested that changes in travel behavior are a complex response including direct, indirect, and induced demand effects. Empirical evidence suggests that some or even most of the congestion reduction benefits of capacity expansion will be lost over time (although at a higher throughput), and challenges the notion that transportation projects can substantially reduce traffic congestion in the long term. Some argue that because of unanticipated induced demand, the congestion reduction impacts of a project may be underestimated and thus falsely justify highway-induced sprawl development patterns and inefficient land use. Other studies note that even with limiting congestion relief, traffic widening projects provide benefits in reducing the duration of peak periods, carrying more vehicles per hour, and supporting access to a larger choice of home and job locations.

New corridor capacity improvement results in the following changes in travel behavior. The first is considered a direct effect, the second an indirect effect, and the third and fourth are induced effects.

Shifts in route, mode, and time-of-day. Improved accessibility shifts trips to the new (less congested) facility through a user's change in route, mode, or from off-peak to peak period. These direct effects imply a simple shifting of trips generated by existing land uses.

Shifts in destination choice. Increased accessibility to existing land uses stimulated by transportation improvements makes it easier for travelers to reach these destinations, resulting in higher than anticipated travel demand in the improved corridor.

Changes in land use. New or changing lands uses result from improved transportation accessibility and alter travel. (Attributing causality of such development to the transportation improvement, over other variables, is often difficult.)

New trips. The least substantiated and most controversial response to transportation improvements is the potential of the improved facility to encourage more travel (e.g., increased trip generation rates). These effects are generally attributed to latent demand in the system discouraged by existing travel costs/congestion.

2.1. Induced demand often exceeds traffic forecasts.

The difficult question for transportation planners is whether traveler response, including direct, indirect and induced travel, is sufficiently large to offset a project's intended travel time savings, eroding its expected benefits. While the literature overwhelmingly accepts the notion that induced demand exists, the quantification of its effects is less understood. Published literature suggests that for every 10% increase in lane-miles, long-term induced travel impacts range from 0-10 percent of initial traffic forecasts. This range of findings is consistent with studies indicating that heavy road building has not abetted US metropolitan congestion; however, each of the studies uses different models, assumptions and/or definitions.

Case Study Evidence:

- A review of four induced demand studies from the 1970s found estimates of 0.1-1.5% increase in travel for every 10% increase in roadway miles.[42]
- Another recent review of 4 studies found 3-10% increase in travel for every 10% increase in roadway miles. [43]
- A separate study of 70 US urban areas estimated that a 10% increase in highway lane miles led to an 8.5% increase in travel, with a lower 7.6% effect for principal arterials.[44]
- Using travel time improvement instead of lane miles, one study estimated a 2.7% increase of travel with a 10% increase in travel time savings, increasing to 5.1% when accounting for long term land use changes.[45]
- A recent study indicated that a ***10% improvement in travel time is associated with a 5% increase in the amount of driving***. That is, half of the new highway capacity is filled with driving that would not have occurred if the road space had not been added.[46] Other studies have shown that ***a 10% travel time improvement results in 2.7-5% increase in driving in the short run, and a larger 5.1-10% in the long term.***[47]
- An extensive 1994 UK Study on induced travel submitted overwhelming evidence that induced demand (growth in traffic beyond route shifts) does occur, although its size and significance varies greatly, and the ability to identify the magnitudes of specific components is lacking.[24]
- Sophisticated modeling of new beltway sections and HOV lanes in the Sacramento, CA metropolitan area estimated an overall VMT increase of 13-18%. Over half of the impact was attributable to changes in destination choice, with new land uses (employment and population location/available land) contributing the rest.
- ***Caution should be used in assessing these values as it is likely that the studies differ in their definition of induced demand (which of the categories identified above), region of analysis (larger regions typically show less net change), and variation in travel costs and other influencing local factors.***
- Research shows that ***when shopping opportunities are available nearby, people make more shopping trips, including spur of the moment purchases*** that might otherwise not be made. [48]Other studies have found that people who live far from shops and other services (lower accessibility) have very efficient trip patterns and less frequent trips.[49]
- An early 1940s historical review of two highway projects in New England (Merritt and Wilbur Cross parkways between New York City and New Haven, CT) that significantly reduced both peak and off-peak travel times, exhibited a 20-30% increase travel over a control group and/or gas sales indicators.[50]
- A US stated preference survey on traveler's response to travel time changes concluded that current travel forecasting practices likely under predict the number of trips induced by major new highway capacity projects by 3-5%, without considering long term (land use) effects. [51]

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42 Ruiter, E., Loudon, W., Kern, C., Bell, D., Rothenberg, M., Autsin, T., "The Relationship of Changes in Urban Highway Supply to Vehicle Miles of Travel," Final Report (preliminary draft). (March 1979)

43 Rodier, C., Abraham, J., Johnston, R., Hunt, J.D., "Anatomy of induced travel using an integrated land use and Transportation Model in the Sacramento Region," TRB Annual Meeting. (2001)

44 Marshall, N., "Evidence of Induced Demand in the Texas Transportation Institute's Urban Roadway congestion Study Data Set," TRB conference. (2000)

45 Burright , B., *Cities and Travel*. Garland Publishing, New York. (1984)

46 STPP, "Why are the Roads so Congested? A companion Analysis of the Texas Transportation Institute's Data on Metropolitan Congestion," (November 1999)

47 Burright, B. "Cities and Travel," in Outstanding dissertations in Economics, Garland Publishing. (1984)

48 Handy, S., " Methodologies for Exploring the Link Between Urban Forma and Travel Behavior," *Transportation Research, Part D*, 1:2. (Dec 1996) and previous work.

49 Ewing, R., P. Haliyr, and G. Page, "Getting Around a Traditional City, Suburban PUD, and Everything In-Between." TRB Annual Meeting. (1994)

50 Jogensen, "Controlled Access Expressways in Urban Area – A Symposium," Highway Research Board Bulletin. (1950)

51 Dowling, R., Colman, S., "Effects of Increased Highway Capacity: Results of a Household Travel Behavior Survey," Highway Capacity Expansion and Induced Travel – Evidence and Implications. TRB, NRC, pp. 21-32. (Feb 1998)

- A recent report to the US Congress noted that widening of major roads does not avert congestion, but may have other benefits. "Triple convergence" (the shift of trips to the improved facility from alternate routes, times, or modes) soon returns peak-hour congestion to the pre-investment level. Nonetheless, the ***highway widening may accrue other benefits, such as a reduced length of the congested peak period, and the ability to move more vehicles per hour during these peaks***.[52]
- The same expert noted that congestion is an equilibrating mechanism between workplace and home location choices. Prior to the auto, people had to live close to their jobs at densities higher than most people preferred. Thus, ***congestion is a price we pay for a much wider range of job and housing choices***. [53]
- A British household survey noted latent travel demand under congested conditions. ***When queried about their response to less congestion, 21% stated that they would drive more, with 2-6% expected to change their trip time or mode***.[24]

[52] Downs, A., Testimony to the Subcommittee on Highways and Transit of the Committee on Transportation and Infrastructure, US House of Representatives (March 2001)

[53] Downs, A. "The Costs of Sprawl – And Alternative Forms of Growth," CTS Transportation Research Conference, Minneapolis, MN. (May 1998)

2.2. Local conditions affect the level of induced demand

The extent of traveler response to transportation improvements is closely tied to local conditions, including the existing level of congestion (i.e., high levels of congestion imply larger traveler response to increases in supply).

Case Study Evidence

- An extensive 1994 UK Study on induced travel concluded that ***induced traffic is of greatest importance where: (1) network is operating or is expected to operate close to capacity; (2) people are very sensitive to congestion, typically in metropolitan and urbanized areas); (3) investment causes large changes in travel costs***. Additionally, pre-existing circumstances, such as upstream or downstream bottlenecks and parking costs make a difference. They note that US induced demand response would likely be larger than that found in the UK due to significant gas price differences.[24]
- The above study found that of 151 UK Department of Transportation improvements the most frequent unanticipated induced demand response appears to occur in major new freeway (motorway) and bypass/ beltway facilities, with less induced response with roadway expansion (on-line) and rural facility improvements.
- Induced traffic effects can work in reverse, when transportation capacity is reduced. A comprehensive study that included review of 49 international case studies found that in most situations a significant portion of vehicle travel was eliminated altogether.[54]

[54] Cairns, Hass-Klau and Goodwin, "Traffic impact of highway capacity reduction: Assessment of the Evidence," London Transport Planning. (1998)

2.3. Truck responses to congestion are limited; they are more time-sensitive.

Trucking industry travel responses appear similar, but less pronounced, than the average traveler. The trucking industry has been innovative in working around congestion, where possible. This has primarily involved shifting to off-peak hours and alternate routes, since there is less ability to shift modes and destinations, particularly for local trips. Some truck operations, such as Less-than-truckload (LTL) and operations tied to business hours, are harder hit as they have less flexibility in routes and schedules.

Historically, the low cost of transportation has led to technological improvements and allowed the substitution of transportation for higher cost production factors (i.e., labor, materials and land). This is reflected in the trends toward outsourcing of manufacturing and assembly work overseas, Just-in-Time (JIT) manufacturing and distribution systems which substitute more frequent truck deliveries for reduced inventory, and expansion of exurban distribution and warehousing centers. These increase opportunities for efficient loading and unloading to serve local destinations, and offer greater travel reliability.

Case Study Evidence:

- Freight induced demand effects are not significant in the short-term. This is due to the marginal nature of most changes in highway capacity today, moderate exposure of trucks to severe congestion, and the overriding influence of low freight transportation costs.[55]
- Many companies that rely on accessibility for goods movement have found ways to work around the costs of congestion and lack of transport reliability in the short term and through structural changes in the long term. Congestion may lead businesses to increase inventories, increase hours of operation, use alternative routes, build satellite facilities and ultimately move their operations to less costly locations. To mitigate lack of transport reliability, firms build buffers into their manufacturing processes and delivery schedules, to avoid expensive production line shutdowns and inability to meet delivery schedules. [55]
- Although most trucks can travel off-peak, some operations require travel during congested peak periods. For many trucks, trip times are driven by uncongested parking and open docks, often available in the early morning and evening hours (outside of the peak travel hours). Other trucking trips, particularly long distance routes, are flexible in their trip times. However, ***local courier, parcel service and less-than-truckload carrier operations have less flexibility in avoiding peak periods*** as they are tied to business hours. They are thus more sensitive to highway capacity changes. [55]
- ***Analysis of congested facilities found trucks have already diverted to off-peak hours where possible and suggests that increased capacity will likely result in a shift back to peak periods.*** A 1988 California study of truck traffic in Los Angeles, San Diego, and San Francisco found that large trucks account for less than 5% of vehicles on the freeways during the peak periods, especially on most congested roads, with highest truck use during the midday off-peak period. Additionally, the Hudson River Bridge in New York/New Jersey has shown a shift in truck trips away from morning and midday hours, attributed to increased congestion between 1985 and 1991.[55]
- Alternate routes, modes, and destinations are often unavailable to goods movement traffic in the short term. Rerouting around congestion is an option for small delivery trucks (e.g., Fed Ex provides drivers with delivery points and deadlines, not sequences). However, larger trucks are often constrained to a specific sequence of deliveries (e.g. first in – last out). Modal shifts are increasingly used, primarily for longer trips, and largely driven to cut overall transport costs. However, ***a key role of trucking in a metropolitan area is local distribution that must utilize the local roadway network***. Change in destination is also less of an option for trucks, although avoidance of congestion has aided in the development of satellite terminals for service-delivery firms.[55]

[55] Grenzeback, L., "Impact of Changes in Highway Capacity on Truck Travel," Appendix C, *Expanding Metropolitan Highways: Implications for Air Quality and Energy Use*, TRB SR 245. (1995)

- In the long term, trucking may be more sensitive to congestion due to structural changes in the trucking industry. The dispersed metropolitan locations of businesses and consumers, and streamlined business practices (e.g. JIT) have led to longer/more time-sensitive supply chains and distribution networks. Such operations are more sensitive to travel reliability and give less flexibility for retiming or rerouting shipments in response to congestion. JIT operations, increasingly being used in the timely delivery of high-value, time-sensitive goods to national and international markets, reduces expensive inventory costs (often 30- 70% of assets) and may result in reduced demand for warehousing facilities.[55]
- A recent study found that ***travel time predictability, for trucks is valued twice as much as overall travel time savings***.[56]
- ***Historically, transportation investments that lower travel costs, such as the interstate highway system, have spurred companion innovations, particularly for distribution/warehousing businesses.*** The improved safety of freeways for large vehicles led to today's high reliance on a reliable trucking industry. Improved highways also allowed the use of larger trucks, changing the nature of the warehousing industry by supporting the replacement of dispersed locations that served multiple clients with consolidated locations operated by individual retailers.[57]
- Savings are not confined to travel time; a recent survey that found a 20% travel time improvement would save $83M for 13 surveyed industries also showed that 38% came from logistics response benefits beyond strict time savings.[58]

[56] Small, K., Nolan, R., Chu, X., Lewis, D., "Valuation of travel time Savings and Predictability in Congested Conditions for Highway User-Cost Estimation," NCHRP Report 431. (1999)

[57] Parsons Brinckerhoff, and Pucher, J., "Consequences of the Interstate Highway System for Transit: Summary of Findings," TCRP Report 42. (1998)

[58] Hickling Lewis Bord, Inc. "Measuring the Relationship Between Freight Transportation and Industry Productivity, Final Report," Prepared for the NCHRP, NCHRP 2-17(4). (1995)

3. HOW CAN PUBLIC POLICY SHAPE THE RESULTING GROWTH?

When significant land use impacts are observed, they are as likely to result from local land use plans, policies, and political structures as from the transportation investment's accessibility benefits. Indeed, if land use policy were completely effective no one would expect capacity enhancements to result in induced travel. Strong land use planning would effectively disconnect the land use response of developers to changes in the transport network. Development due to improved accessibility would thus follow comprehensive land use plans, rather than induce sprawl.

3.1. Land use planning methods and policies affect development patterns and travel behavior.

Integrated transportation-land use policies, plans and projects influence the pattern of development, which in turn affects the location of households and employment. Government policies impact land prices and thus impact urban form. Locations with strong land use controls and public policies held fast under developmental pressure, have been successful in balancing jobs-housing, mixing land uses, and providing travel choices that reduce VMT growth which can lead to excessive transportation infrastructure costs.

Table 2 is a summary of planning tools used to manage the land use benefits and costs of transportation projects. The tools are grouped by objective: (A) managing long term growth through long term plans, (B) influencing site plans as development occurs; (C) preserving rural/open space from development; (D) transportation design standards to effectively integrate land uses; (E) demand management to preserve available transport capacity for its highest use; and (F) cost recovery of development-induced public infrastructure investments. Despite the vast literature on methods and use of the various land use planning methods used to control development, little is available on their impacts. The evidence, where available, is discussed following the table, grouped by the above objectives.

Table 2. Planning Tools to Manage Development from Transportation Projects

Policy Tool	Desired Effect
A. Managing Long-Term Growth	
Concurrency Requirements (e.g., WA Growth Management Act)	Mandates that public services and infrastructure be provided coincident with development in order to prevent premature urban development.
Comprehensive Plans and Periodic Review (e.g. OR)	Mandates process for growth management in local comprehensive plans and their periodic review
Focused Public Investment Plans (FPIP)	Targets public service investment to control development (e.g., effective when combined with require service availability as a precondition of development approval).
Extension of Public Transportation facilities far in advance of development	Constructs public transit in areas currently undeveloped but planned for future urbanization in order to reduce ROW costs, and guide development by influencing land values and land desirability.

Policy Tool	Desired Effect
Construction in Phases	Allows accessibility improvement to accrue over a longer time period, so the associated development proceeds more slowly, and limits overwhelming development pressures. Phase specific locations and associated construction delays to avoid "undercutting" of existing development vitality.
Interchange Location and Timing	Specifies plan details regarding interchange location and construction staging in order to avoid premature, auto-oriented development.
Phase Freeway Construction with Arterial and Collector System	Establishes local road system prior to freeway construction, typically results in a more compact land development framework.
Jobs/Housing Balance	Identifies and promotes balanced job and housing targets and the formal/informal policies for their achievement (e.g., new employment requires a housing component, commercial/ industrial development must meet current/future residents, promotion of housing development near large employment centers).
Targeted Land Development	Promotes specific land use development near transit stations, near highway interchanges, or in infill/downtown reinvestment.
Interchange Development Zoning	Regulates the type of development that can take place at an interchange or along connecting arterials.
Alternatives to Traditional Zoning Practices:	**Planning Policy Guidance Notes (PPG) (UK)** -- Replaces traditional zoning with policy statements that carry the force of law and spell out what is allowed in a broad sense. County and local plans must conform, with some flexibility. **ABC System (Netherlands)** – Establishes planning guidelines that match types of transportation requirements of different land uses with the type of accessibility of different locations.
B. Influencing Site Plans	
Implementation of: **Current State Land Use Laws** and **Local Land Use Policies and Plans**	Implements state and local land use plans on a day-to-day level, standing firm against development pressures to alter plans from their original intent.
Special Corridor Zoning and Design Standards	Applies rigid zoning (e.g. zone overlays) and design guidelines (e.g. restrict access points) to specially designated corridors in order to protect roadside environment, prevent strip development, and preserve landscape, assist orderly development and promote safety.

Policy Tool	Desired Effect
Specific Development Plans	Coordinates development (over piecemeal) of one or more properties to define the type and mix of land uses, associated design standards, available public facilities, and schedule for development.
Minimum Densities	Requires residential development meet an average number of dwelling units per land area, promoting compact urban form and reducing pressure to develop rural land.
Transit Oriented Development (TOD) **Traditional Neighborhood Design (TND)**	Promotes urban form characteristics that support transit use and non-motorized travel through appropriately mixing of necessary land uses (e.g., shopping near residents).
Site design Standards	Specifies development look/feel to facilitate non-motorized travel options.
C. Preserving Rural/Open Space	
Urban Growth Boundaries (UGB) and **Annexation rules** (e.g., ORS 198)	Limits land development outside of a designated boundary; include specific process to review the boundaries in light of future region growth expectations.
Public Land Acquisition	Purchases public land through bond levies or dedications in order to preserve landscape, habitat, historic vistas, and/or control development near transportation improvements (e.g. interchanges).
Conservation Easements, **Transfer of Development Rights** (TDR) **Transferable Development Credits** (TDCs) **Density Transfers**	Limits allowable transfer of a property's development rights to protect land or transfer rights to a more desirable location.
Differential Tax Assessment	Taxes to discourage conversion of farm/ forestland to other uses through tax incentives (for maintenance of existing zoning) and disincentives (on conversion).
Exclusive Farm/Forestry Use Zoning (EFU) **Non-Exclusive Use Zoning** **Voluntary Agriculture Districts**	Zones based on location (e.g. outside UGB) and soil classification to limit use and lot sizes in order to preserve farming and prevent rural residential subdivisions.
Right-to-Farm Laws	Protects farmers from nuisance suits brought by neighboring residents that could restrict farming operations.
Rural Zoning for Non-Resource Use **Urban Reserve Planning Restrictions (OR)**	Zones land for rural residential, rural commercial, or rural industrial use, typically with relatively large lot residential or limited to specific types of commercial/industrial uses.

Policy Tool	Desired Effect
Land Trusts	Sells or donates land (land trusts) to a local nonprofit, tax-exempt corporation empowered to accept and manage land to preserve open space and natural resources.
Land Exchanges	Transfers land ownership (or certain rights) in order to improve the value of the land or adjoining lands and transfers development rights to more desirable location.
Land Banking **Public Land acquisition**	Purchases land in advance of development, often at the urban fringes, to control how and when land is developed promoting preservation of landscape, habitat, historic vistas, and control development (e.g., near interchanges).
Greenbelts **Green Corridors**	Designates reservation of specific land or corridors as a link between adjacent urban areas. Such areas can be managed by intergovernmental agreements with county management and or amending of comprehensive plans. Promote focused community development/identity, prevents urban sprawl and provides permanent open space around urban areas.
D. Transportation Design Standards	
Intersection Control/Access Management	Plans traffic signal timing and development access roadways to ensure more efficient development patterns while promoting traffic safety and efficiency (e.g. access roads, curb cuts, signal timing, left turn lanes).
Design Standards for Transportation Corridors	Establishes design standards to govern a range of concerns within a transportation corridor in order to prevent undesirable land uses and incoherent interchange development.
E. Demand Management	
Transportation Demand Management (TDM)	Promotes public/private programs that reduce the demand for travel (e.g., trip reduction ordinance, modified work schedule, private bus/van pools).
Provide/Encourage Transportation Choices	Constructs or promotes non-single occupancy auto usage, primarily for commuting (e.g., park and ride lots, transit fare discounts, new rail stations).
Intelligent Transportation System (ITS) Technologies	Implements new ITS technologies to improve efficiency and throughput of transportation infrastructure.

Policy Tool	Desired Effect
Tollways **Congestion Pricing**	Rations routes by time or cost, possibly favoring some modes/activities and time-of-day in order to preserve peak-period highway capacity for those who value it the most (e.g., ramp metering, HOV or truck-only lanes, peak period pricing). Use revenues to pay for the construction and/or maintenance of facility or offset congestion costs for specific locations/users.
Parking Supply Management **Parking Pricing**	Rations supply or price parking (e.g., no free parking), particularly in employment centers. Use revenues to pay for the construction and/or maintenance of facility or offset costs for specific locations/users.
F. Cost Recovery	
Windfall Tax	Taxes expected increase in land value with transportation improvement in order to provide funding to offset associated development costs.
Impact Fees **System Development Charges (SDC)**	Taxes development to fund transportation and other infrastructure necessary to support the new development. SDCs are dedicated for specific capital projects.
Development Cost Reductions	Reduces development fees (e.g., density bonuses, redevelopment subsidies, infrastructure financing) to encourage favored land use development.
Taxation Mechanisms	Modifies state, local, and federal, income, sales, and property taxes to promote cost recovery or influence business or residential location decisions.

Case Study Evidence:

A. Managing Long-Term Growth

- *Toronto has effectively improved the balance of jobs and housing.* With the objective to balance substantial new office construction the city accelerated substantial new housing construction downtown using bonuses for development near rail stations and imposing restrictions on areas away from stations. Surveys showed that many workers were, as a result, able to live near their new jobs, while commute trips into downtown increased less rapidly than without such efforts.[59]

- ***Much of San Francisco BART rail transit impact of high-density station development is attributed to public policy actions***. These include tax increment financing, new incentive zoning (increased floor area ratios within 700 ft of station), density bonuses for buildings adjacent to stations, and assistance with land assemblage. Some stations exhibited less development due to local opposition, existing market conditions, or a location in a highway median. [7]

[59] Nowlan, D. and G. Stewart, "Downtown Population Growth and Commuting Trips: Recent Experience in Toronto." *Journal of the American Planning Association*, Vol. 57, pp. 165-182. (1991)

- ***Strong state and local comprehensive land use plans and urban growth boundaries have been effective in reducing the impact of transportation investments in Oregon, according to a recent study***. A recent study looked at the direct and indirect impact of highway widening/realignment improvements for 6 Oregon cities at the urban fringe (primarily inside urban growth boundaries). All illustrated that development that occurred within 10-15 years of the highway improvement was generally consistent with the development envisioned in local plans prior to the improvement. The lack major new developments occurred outside the UGB in these areas, despite the highway investment, was attributed to effective state policies that restrict development of resource lands.[23]
- In the above Oregon case studies, ***lack of sewer and water capacity in at least 2 fringe cities was found to be a major limiting factor on development*** following highway widening projects. In one case, it was difficult for any one development to absorb the cost of service extension across a flood plain (Albany). In the second, public plans did not anticipate the needs of large-scale retail (Wal-Mart) interested in the site after highway expansion.[23]
- ***A Focused Public Investment Plan (FPIP) has been an effective tool to focus development in Salem, OR***. The city provides much lower cost share in areas outside its capital improvement investment area, even though still within the city's UGB. The success was supported by a long-term political commitment of plan adherence and the ability to readily separate a large contiguous undeveloped area available at program inception (1978) along natural and political boundaries. [67]
- Current Plans underway in Riverside County, part of Los Angeles will identify long-term right-of-way preservation for multi-modal (including transit) corridors needed to accommodated expected growth. The project is bringing together stakeholders representing the County General Plan, County Multiple Species Habitat Conservation Plan (MWSHCP) and the transportation focused Community and Environmental Transportation Acceptability Process (CETAP). The effort will concurrently consider transportation, land use, and biological resources.[60]

B. Influencing Site Plans

- Policies that can induce mixed land use and higher densities around transit investment include regional coordination of local land use and transit plans, favorable station traffic and parking policies (e.g., restricted parking and amenable pedestrian access), and infrastructure and financial incentives to support near-station development.[61,62]
- ***Increased residential density has been shown to reduce vehicular travel***. A study of 1990 US data found that a 10% increase in density leads to a 0.7% reduction in household auto travel.[63] In another study, doubling residential densities in San Francisco neighborhoods, after controlling for transit service and vehicle ownership, was associated with 16% lower vehicle miles of travel (VMT). [64] A third study of residential density on commuting behavior across US cities, suggests that a threshold density of 10,000 person per square mile minimizes auto commute times, with congestion effects at such densities limiting driving, and transit mode shares increasing above this density.[65]
- ***Increased density also reduces auto travel by providing the critical mass needed to support transit.*** A study of transit in several US cities studied such relationships in 11 light rail and 6 commuter rail regions. For light rail, the study found that a 10% increase in residential density yields on average 5.9% more riders per light rail and 2.5% per commuter rail station. Likewise, a 10% increase in CBD employment density increased light rail boardings at stations outside the CBD by about 4 % for light rail and 7.1% for commuter rail, holding other factors constant.[66]

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60 Smith, S., Bechtel, C., Studor, E., Placilla, M., "The Riverside County Integrated Project: A Bold Approach to Multi-Disciplinary, Concurrent Decision-Making for Transportation, Land Use, and Habitat conservation," Transportation Research Board Annual Meeting. (2001)

61 Cervero "Exploring the land Use Potential of Light Rail Transit," TRR 992 (1984) and Emerson, D., "Framework for Analyzing the Impact of Fixed Guideway Transit Projects on Land Use and Urban Development," TRR 1274. (1990)

62 Knight, R. L. and L. Trygg, "Evidence of Land Use Impacts of Rapid Transit Systems." *Transportation*, Vol. 6, pp. 231-247. (1977

63 Schimek, P., Household motor Vehicle ownership and Use: How Much Does Residential Density Matter?" *Transportation Research Record* 1552. (1996)

64 Holtzclaw, J., "Using Residential Patterns and Transit to Decrease Auto Dependence and Costs," Natural Resources Defense Council, San Francisco. (1994)

65 Levinson, Kumar, "Density and the Journey to Work," Growth and Change. (1997)

66 Parsons Brinckerhoff, "Transit and Urban Form," TCRP Report 16. (1996)

C. Preserving Rural/Open Space

- ***Concurrency management*** can affect the timing of development and avoid congestion. However, some programs have encouraged sprawl and increased travel, while others using multi-modal or district measures have supported infill, compact development and transit use. Programs are in effect in Florida, Washington state, and Montgomery County near Washington DC.[67]
- ***Public purchase of land*** has been effective in urban areas of Oregon and Colorado for preserving land and open space. Oregon programs include the Metro Greenspaces program and the Willamette River Greenway. Near Boulder, CO, voters approved the acquisition and management of 18,600 acres of wildlife habitat, unique geologic areas, and farmland, using sales tax revenues.[67]
- ***Transfer of Development Rights*** (TDR) programs used to protect open space, are found in Montgomery County, MD, New Jersey Pinelands, Malibu/Santa Monica Mountains, CA, the California Coastal Commission, and the Tahoe Basin in CA/OR. [67]

D. Transportation Design Standards

- ***Access management*** has been used as a tool for growth management and efficient land use control in Colorado, Florida, New Jersey, and portions of Vermont, and Newfoundland and Labrador Canada. Typically a permitting process is required for properties seeking access to a state highway or where substantial change in land use occurs that my impact trip generation rates. Some use formulas to assess permits, while others tie processes to local comprehensive planning.[67]

E. Demand Management

- The literature has suggested that passive ***travel demand management*** (TDM) (e.g., ridesharing policies) has had little effect on travel behavior. The limited financial incentive for participation in such programs was one reason cited.[68]
- One review of 23 tactics to relieve peak hour congestion relief concluded that considering the effectiveness, cost, implementation requirements, and political acceptability, ***pricing tactics*** were felt most effective. Additionally, few tactics reduce traffic congestion by themselves, even if widely applied, promoting a multi faceted approach. The top tactics (if applied consistently throughout a metro area) were peak-hour road pricing on major traffic arteries and charging a sizable special fee for all AM peak hour parking.[69]
- A study of San Francisco Bay Area between 1980-1990 noted that auto occupancy in some areas was highly influenced by aggressive ridesharing programs. Despite a 3-4%, regional decline in auto occupancy during the period, higher occupancies were maintained in downtown core areas and increased in selected areas (San Ramon and Pleasanton) with ***aggressive ridesharing programs, developed in response to local trip reduction mandates***.[6]
- ***Parking pricing and management*** reduces parking demand and making it possible to increase development density. This effect would be most pronounced in CBD or other congested employment centers, because increased land values also increases parking values. Case studies indicate that the average ***solo driver share of commute trips falls from 67 to 42% when the employee, rather than the employer, has to cover parking costs.*** A Southern California study of current suburban parking policies noted that in the 1990s, average peak utilization of parking facilities was 56%, contributing to lower development densities. It was important to eliminate counter productive policies, such as tax deductions and incentives. Additionally, lack of downtown reinvestment allows surface parking to be more profitable than older office space as demonstrated in Kansas City and Columbus.[70]

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[67] Parsons Brinckerhoff, "Methods of Managing the Land Use Impacts of the Sunrise Freeway," ODOT. (July 1999)

[68] Parsons Brinckerhoff, "Land Use Impacts of Transportation: A Guidebook," NCHRP Report 423A. (1999)

[69] Downs, A., *Stuck in Traffic: Coping with Peak-Hour Traffic Congestion*, The Brookings Institute and Lincoln Institute of Land Policy. (1984)

[70] Shoup, D. C., "Cashing Out Employer-Paid Parking: A Precedent for Congestion Pricing?" *Curbing Gridlock*. Transportation Research Board, pp. 152-199. (1994)

- Calgary's comprehensive ***ownership and management of downtown parking supply*** has been effective in reducing downtown auto travel, and boosting transit ridership. The city operates a significant share of total long-term parking downtown, and providing the highest number of park-and-ride spaces per capita in Canada. The program was initiated in the 1980s. During that period, the city intentionally accompanied CBD job growth with a slower growth in parking within the city, effectively constraining supply and encouraging transit use to downtown. The program has enabled employment increases without meaningful increases in parking supply, leading to more productive uses of scarce CBD land.[71]

F. Cost Recovery

- Changes in ***local taxation policies***, though difficult to implement can be effective. A study, which attempted to determine the effect of local taxes on the location of commercial and industrial within metro areas, concluded that a wide variety of state and local economic taxation policies can significantly affect the long-run growth patterns of cities. It found the long-run effect from seven economic studies in the 1980s implied that a 10% increase in local tax burden resulted in a 10% reduction in employment (measured elasticities ranged from –4.43 to 0.62, centered on –1.9).[72]
- ***Shared local sales or property tax programs*** have changed new commercial development patterns and associated travel behavior in portions of the Minneapolis Twin Cities area. Pooled taxes are distributed to cities, counties, and special districts using a formula based on the property tax wealth and population of each jurisdiction Some portions of the region showed less success because only a small portion of the commercial taxes were shared, providing little incentive to stop development competition.
- ***Higher fuel taxes*** have been shown in the long run to result in revenues and promotion of fuel-efficient vehicles, rather than changes in travel behavior.[69]
- ***Pricing (e.g., congestion or parking)*** is a potentially powerful tool for changing travel behavior and thus land use. However to offset the heavy toll on high employment center, pricing revenues should be used to increase capacity or reduce other costs to these areas (e.g., taxes). A congestion pricing toll was imposed in Seoul, South Korea in its Nam Sam Tunnels in 1996. The program reduced traffic volumes by 14%, increased speeds by 65%, and increased carpooling (no toll) from 7 to 20%, after 7 months.[73]

71 Parsons Brinckerhoff, and Pucher, J., "Consequences of the Interstate Highway System for Transit: Summary of Findings," TCRP Report 42. (1998)

72 Bartik, T., "Who Benefits from State and Local Economic Development Policies?" Upjohn Institute for Public Research. (1991)

73 USDOT, "Reducing Traffic Congestion" Report to Congress (1999)

3.2. Metropolitan political systems affect land use outcomes.

Metropolitan development patterns are intrinsically political; local policymakers (and the pressures they face) largely determine the intensity and type of development on a given property. Indeed, politics and policy can have a large impact on the concentrations of poverty and affluence, the aesthetic character of suburban growth patterns, and other "urban problems" such as traffic congestion and air pollution. Additionally, business climate and public support of local land use plans can influence resulting development. Table 4 lists some of the effects of such issues, followed by supporting case study evidence.

Table 4. Political Issues Impacting Effectiveness of Land Use Control Measures

Issue	Effect
Metropolitan Fragmentation and Intergovernmental Agreements	Fragmented public sector governance tends to drain existing and new commerce from urban core and be more responsive to narrow or concentrated interests. Local governments compete more with another to gain desirable land uses (few services with high property or and to avoid less desirable ones (expensive services with lower tax returns). Unitary political arrangements present fewer obstacles to natural market processes extend the leverage of visionary administrations.
Business Climate	Perceived perception of "pro-business" climate. Firms like predictability, including streamlined land use approvals, comprehensive land use planning that avoids surprises after investments are underway, and the commitment of region planning institutions to mitigate congestion at/below "tolerable" levels.
Neighborhood Opposition	Opposition to growth and higher density rezoning can be strong, posing an obstacle to the best plans. Responses may include educating residents of alternative actions and involving stakeholders in mitigation plans.

Case Study Evidence:

- An article on metropolitan development noted that fragmentation of governments impedes local land use planning efforts. ***Multiple competing government control*** (e.g., metropolitan Los Angeles consists of over 100 cities and 5 counties, and metropolitan Atlanta has 46 cities and 7 counties) ***allows developers to play one jurisdiction off another***, in attracting their business. Without strong regional control, lack of coordinated actions in land development and transportation and their speedy approval is difficult, often leading to piecemeal development.[3]
- A case study in Woodburn, OR found that highway investment spurred retail outlet mall development at an interchange. In Ridgefield, WA, an existing warehouse, service and rural residence region, zoned for industrial park, has been proposed for re-zoning to support potential retail commercial uses. These cases point out how ***retail uses often develop at interchanges zoned for other uses,*** inducing traffic at these interchanges. [74]

[74] Polzin, S., Green, C., Memo to Portland Metro "I-5 Trade Corridor Study: Case Study of Three Interchanges Along I-5," (June 2001)

- A recent address to the US Congress noted that regional planning is an important component to creating higher densities in urban areas. It states that regional planning and authority over both land use and transportation actions is important to significantly alter existing low-density growth patterns. Local governments on their own seek to benefit their own residents by shifting costs to other localities. ***Without regional governance, no one has political incentive to focus on the well being of the entire region, so it is not well served***.[52]
- A recent study found that the ***change in density*** (people per acre) ***of US urban areas from 1982 to 1997 was significantly and inversely related to the number of local governances*** (city, township and county).[75] That is, the more units of government, the lower the densities of development.
- Neighborhood residents have been shown to resist increased growth from transportation investment; in many cases they have successfully persuaded local jurisdictions to downzone entire areas.[62]

[75] Fulton, W., Pendall, R., Nguyen, M., Harrison, Al, "Who Sprawls Most? How Growth Patterns Differ Across the US," Brookings Institution, Center on Urban and Metropolitan Policy. (July 2001)