Smart Growth and The Transportation-Land Use Connection: What Does the Research Tell Us?

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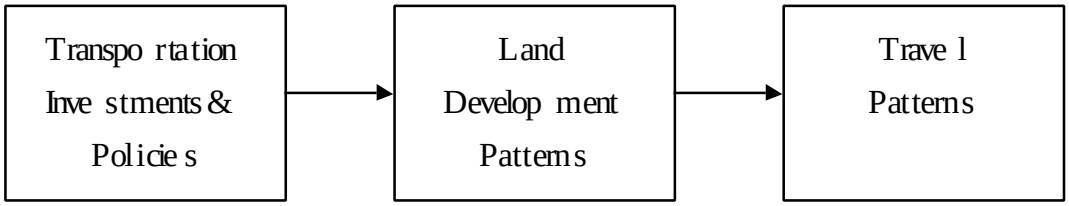
Introduction:



The connection between transportation and land use plays an important role in both explanations of sprawl and estimates of the costs of sprawl. Transportation and land use are inextricably linked in two basic ways and many more subtle ways. First, transportation investments and policies influence development patterns: commercial development stretches out along highway corridors, new subdivisions pop up after the new freeway opens, shopping malls and gas stations congregate at interchanges. In this way, transportation investments contribute to sprawl, but they can also be used as smart growth strategies to help to fight sprawl. Second, development patterns shape travel patterns: the design of suburban areas makes transit and walking a challenge, the separation between land uses in low–density developments makes driving a necessity. In this way, sprawl contributes to automobile dependence, but smart growth policies to fight sprawl can reduce automobile dependence. Both theory and intuition tell us that this is the way the world works. But empirical evidence is surprisingly mixed, at least with respect to the impact we can expect from smart growth policies that depend on these relationships. The mixed evidence leaves plenty of room for debate.

Guiliano, for example, says that "the precise relationship between transportation and land use continues to elude us" and points to "a cluster of unsubstantiated beliefs" about the land use – transportation connection (Guiliano 1995: 3). She has argued that the connection between transportation and land use has weakened, that commute distance, for example, no longer matters so much in the choice of where to live. At the heart of her explanation is the relatively low cost and the relatively pervasive accessibility provided by the transportation system today, so that marginal changes have little impact on either development patterns or travel patterns. She argues for the use of pricing strategies rather than land use strategies to reduce automobile use and against trying to use transportation investments to shape development patterns.

In response, Cervero and Landis (1995) argued that the transportation – land use connection still greatly matters. They accept the premise that transportation costs have declined and accessibility has increased, so that "the connection is undoubtedly much weaker today than it was a century ago," but they argue that transportation investments

"still strongly affect land use patterns, urban densities, and housing prices" in combination with other policies and that "there remains strong evidence that characteristics of built environments… significantly influence travel demand" (pg. 3). Strategies that depend on these relationships "are not panaceas for today's congestion, air quality, or social equity problems," but neither are any other proposals. Land use initiatives remain an important tool for managing transportation demand, they conclude.

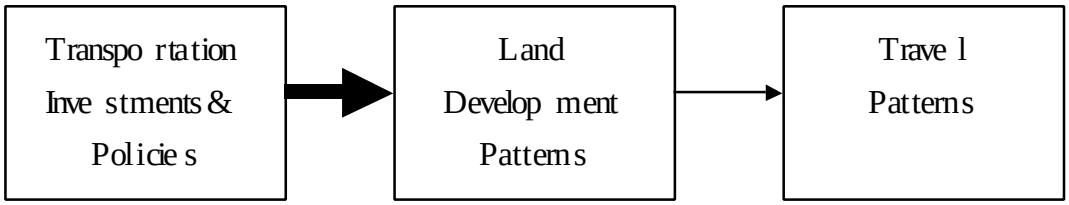
Underlying these positions is some degree of consensus. First, highways have clearly been a necessary but not sufficient condition for suburban growth. While freeway construction enabled the growth of the suburbs, the desire for suburban living is a more fundamental cause. Second, sprawl has been a sufficient but not necessary condition for automobile dependence. Although sprawling patterns of development make driving a practical necessity, it is possible to find high levels of automobile use in places that are not sprawling. Most participants in the debate agree on the historic strength of the connection between transportation and land use, but diverge on the current and future strength of this connection. How much impact do new transportation investments have on development patterns? How much impact do changes in development patterns now have on travel patterns? Realistically, only marginal changes in existing transportation systems and development patterns are possible at this point, so that the debate boils down to the question of whether marginal changes will have more than a marginal impact.

Several specific assumptions about the relationships between transportation and land use, some related to the causes of sprawl and some to its solutions, are commonly made by proponents of smart growth. These assumptions include (but are not limited to) the following:

- Building more highways will contribute to more sprawl.
- Building more highways will lead to more driving.
- Investing in light rail transit systems will increase densities.
- Adopting New Urbanism design strategies will reduce automobile use.

But are they right? This paper explores how well the available evidence supports these four assumptions. Although far from exhaustive, the review that follows provides an overview of the theory, research efforts, and current debates associated with each of these assumptions. Although the connections between transportation and land use at first brush seem both obvious and simple, our appreciation of the complexities of these connections increases as the research on these connections progresses: the more we know, the less we seem to know. Researchers have made more progress on some of these assumptions than others, but even in the best cases, our ability to predict the impact of different policies remains limited.

Assumption 1: Building more highways will contribute to more sprawl



The unprecedented construction of freeways that got underway in the 1950s has often been blamed for the explosive expansion of suburban areas that got underway at the same time. Although freeway building has slowed considerably since then, many metropolitan areas are still planning new facilities that will serve relatively undeveloped areas. In the Austin region, for example, at least three major new freeways are planned in the next decade or so, all serving areas that are expected to grow rapidly in the near future. Such plans seem clearly to conflict with the tenets of smart growth because of their potential to increase sprawl, defined as the low-density, auto-oriented spread of metropolitan regions. In a campaign flyer for a bond election in Austin in 2001, the Austin Neighborhoods Together PAC argued that "The $185 million Travis County Bond Package will cause pollution by… extending roads into far-flung areas outside the city that will increase sprawl and air pollution."

Economic theory explains the connection between highway construction and both expanding boundaries and decreasing densities in metropolitan areas. Commuters make trade-offs between land costs and commute costs, so that they are willing to pay more for housing that minimizes their commute and can afford to pay less for housing the farther they commute. Where commuters live depends on their household budgets, their preferences for space, and competition with other commuters for different locations. In this model, a decline in transportation costs means that commuters can live farther from work or buy a larger house at the same location without an increase in budget. Both options tend to increase sprawl. An increase in income has the same effect, enabling commuters to afford more house and/or more commute. This model, despite simplifications, provides a convincing explanation of the expansion of metropolitan areas in the US over the Twentieth Century as travel costs declined and incomes rose. The question for today is whether new investments significantly reduce transportation costs.

Economic theory also suggests that the amount of development a particular location will attract depends on the accessibility of that location relative to others. Transportation facilities play an important role in this model by determining the relative accessibility of different locations. Historically, roads and transit services converged on the center of the city, which was the most accessible location to the most people. The first freeways continued this pattern. But the growing web of freeways soon created locations of relatively high accessibility in the suburbs, and development then concentrated at these nodes as well. The value of accessibility is reflected in both the price of land and the

intensity of development. Theory suggests that the increases in price and intensity associated with an increase in accessibility might occur both in total, or what has been called a "generative" impact, and as a result of shifts in development from one location to another, or what has been called a "redistributive" impact (TCRP 1998). The question for today is whether new investments significantly change the relative accessibility of different locations in the region.

The historic contribution of freeway building to suburbanization, at least as an enabling force rather than a causal force, is generally supported by the empirical evidence. In one of the first studies of the impact of highways on development patterns, Garrison, et al. in 1959 found significant changes in the locational patterns of retail business and residential land use in response to highway improvements, including the prevailing tendency for certain types of businesses to locate along highways in the now-pervasive commercial strip. Studies that followed looked at the impact of highways in a variety of different ways. Some studies focused on the impact of highways on overall economic growth, while others explored the distribution of development, usually as measured by property values or population and employment densities. Some studies looked for evidence of impacts at the scale of census tracts or other small areas, while others analyzed the impacts at the scale of counties or metropolitan regions. Much of the research on the impacts of highways on development has focused on non-metropolitan areas, either the impact for communities of being on the interstate system (e.g. Chandra and Thompson 2000) or the impact of the construction of a highway bypass around the community (e.g. TRB 1996).

The debate today is over the degree to which additional freeway building continues to shape development patterns and, in particular, promote sprawl by reducing transportation costs and changing relative accessibilities. Most relevant to this debate are studies of the impact of beltways on development patterns. The widely-cited Payne-Maxie study from 1980 looked at the impact of beltways – "limited access highways partially or completely circling cities" – on development patterns in metropolitan areas. The researchers constructed a sample of 27 U.S. cities with beltways that was matched to 27 U.S. cities without and conducted statistical analyses to compare economic growth and development patterns between the two samples. They found no statistically significant impact on economic growth for regions with beltways, but they did find an impact on development patterns. In particular, office space and apartment buildings tended to locate near the beltway, but impacts on other types of land uses were "weak or non-existent" (pg. 11). In addition, they concluded that a beltway can "increase development opportunities in its corridor, reinforce prevailing urbanization patterns, and facilitate compact development" but that a beltway cannot create a market for development where none would otherwise exist. More recently, Hartgen and Curley (1999) studied the relationships between beltway construction, sprawl, and traffic congestion for the 65 largest urbanized areas in the US between 1990 and 1997. They concluded that urbanized areas without beltways or with just partial beltways actually grew faster in area, population and employment than areas with full beltways, contrary to the assumption that highway building increases sprawl. But population densities declined faster in cities with full or partial beltways than

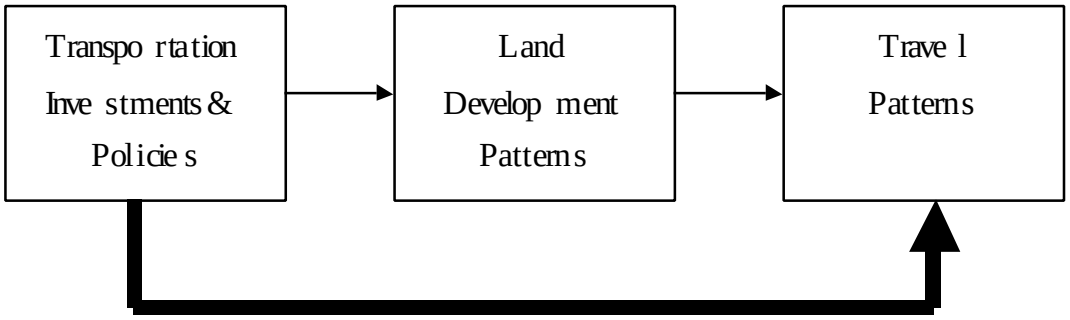
cities without beltways, supporting the assumption that highway building increases sprawl. The evidence from this study is thus mixed.

Two recent studies recently examined the impact of freeway expansion on land development in metropolitan areas. Hansen, et al. (1998) looked at building activity in eight corridors in California where freeway capacity had been expanded in the previous two decades. They estimated models for the share of regional building permit activity in the corridor as a function of several independent variables, including capacity expansion. They found different effects for different types of land uses and different impacts at different points in time: single-family residential building increased "sharply" immediately after the expansion but slowed over time; multi-family residential building followed a similar pattern but slowed more rapidly; commercial development also increased after expansion and for a several years more; industrial development was not immediately affected by the expansion, though it increased in subsequent years. They conclude: "While we acknowledge uncertainty over these details, our results offer strong support for one overriding conclusion: highway capacity expansion stimulates development activity, both residential and non-residential, in the corridors served by the expanded facilities" (pg. 10). Ten Siethoff and Kockelman (2002) looked that the link between property values and highway expansion in a single corridor in Austin, TX in which the highway had been upgraded from an unlimited-access to a wider, limited-access facility with frontage roads. With data on property tax assessments for 300 parcels along the selected highway over a period of 18 years, the researchers estimated a variety of models to test for a significant relationship between the expansion of the highway and property values. They conclude: "the timing of this freeways project's construction and completion were significant events for property valuations" and that "dramatic valuations also accrued to those properties most proximate to the freeway corridor." Although both of these studies demonstrate a significant impact of highway expansion on development in the highway corridor, they did not evaluate changes in other parts of the region to determine if the impacts were generative or redistributive.

These studies and others suggest that beltways or urban highways more generally do not increase the rate of growth but may influence where growth occurs and at what densities. In other words, the available research provides no evidence of generative impacts but does provide evidence of redistributive impacts. Boarnet and Houghwout (2002), in a review of the research on the influence of highways on development for the Brookings Institute, conclude: "In sum, the evidence suggests that highways influence land prices, population, and employment changes near the project, and that the land use effects are likely at the expense of losses elsewhere" (pg. 12). They go on to say that the evidence does not support the belief that highways cause suburbanization, which is driven by a wide range of forces, but that highways clearly influence development patterns: "Yet given that metropolitan areas are decentralizing for reasons that might be unrelated to transportation, highways certainly have the potential to influence the geographic character of that decentralization" (pg. 13). Highway building thus appears to contribute to sprawl not by increasing the rate of growth but by influencing where in the region development occurs and by influencing the character of the development that occurs.

Based on these findings, it is reasonable to conclude that new highway building will enable or encourage additional sprawl to some degree, although to exactly what degree is uncertain and depends on local conditions. However, the converse of this assumption is probably not true: not building more highways will probably not slow the rate of sprawl. If other factors are more fundamental causes of sprawl than new highways, then sprawl may continue even in the absence of new highways. It is possible, for example, that the hope for or expectation of a new highway sometime in the future is sufficient to encourage new development at the fringe.

Proposition 2: Building more highways will lead to more driving



Proponents of smart growth often argue that building more highways will simply lead to more driving, that new capacity will generate new travel and thereby offset any reductions in congestion. Roy Kientiz, for example, while executive director of the Surface Transportation Policy Project, argued in a widely-circulated essay that "evidence shows new roads fuel the already explosive growth in the amount we drive. New and wider roads bring short-term relief, at great expense" (Kienitz 1999). The phrase "build it and they will come" has become a shorthand way of talking about this phenomenon, and references to new freeways or newly expanded freeways that were as congested as the original are common. This growth in traffic occurs in the short run and independently of the growth in traffic that might occur because of the impact of highway building on development.

Sometimes referred to as "induced demand," this phenomenon is more accurately labeled "induced travel." In theory, new capacity reduces the price of travel by reducing travel times and, in economic terms, shifts the supply curve. As the price of travel goes down, the consumption of travel goes up; the supply curve intersects a new point on the demand curve. This effect should occur even without an increase in population, as existing residents choose to make more trips, longer trips, and more trips by car as a result of the decline in price. But it is important to note that only capacity increases that reduce travel times will have this effect. Definitions of these concepts and explanations of this theory are provided by Downs (1992), Litman (2001), Noland and Lem (2002), and Mokhtarian,

et al. (2002), among others. Documenting the extent or even existence of this effect has been a significant challenge for researchers, however. Following a string of studies showing a strong connection, three recent studies failed to find a statistical link between increases in capacity and increases in driving.

The debate over induced travel seemed to have been put to rest over the last decade with series of studies showing a statistically significant connection between highway capacity and travel. In 1995, the Transportation Research Board (TRB) published the report *Expanding Metropolitan Highways* in which an expert panel reviewed the available evidence on the relationships between highway capacity additions, emissions, air quality, and energy consumption and concluded that travel demand forecasting models do not "adequately reflect the effects of reductions in travel time or increased travel time reliability that result from an expansion of highway capacity." A special session on the topic of induced travel was held at the 1997 annual meeting of the Transportation Research Board and summarized in four papers published as a Transportation Research Circular in 1998. The introduction to this circular notes that "the range of disagreement between highway proponents and opponents on the subject of induced travel has narrowed considerably" (pg. 6). The decline in disagreement was attributed to a recognition on the part of highway proponents that new capacity induces a variety of changes in land use and travel behavior and on the part of highway opponents that the induced travel effect is a result of time savings rather than capacity increases per se.

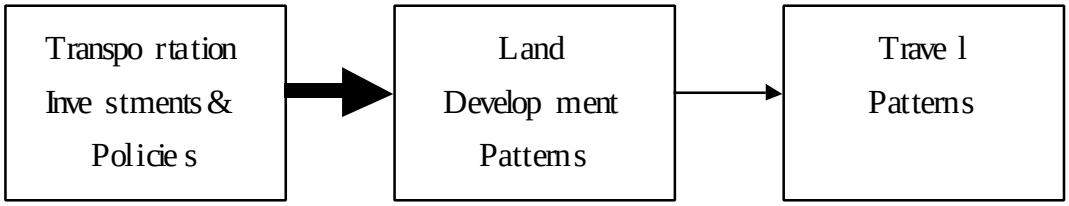
Noland and Lem (2002) reviewed nine studies of induced travel and their estimates of the elasticity of VMT with either travel time or lane miles. The studies reviewed in this paper had consistently estimated elasticities from at least 0.3 to as much as 1.1 for lane miles: a 10 percent increase in lane miles is associated with at least a 3 percent increase in VMT and as much as an 11 percent increase. The elasticities for travel time ranged from –0.3 to –1.0: a 10 percent decrease in travel time could lead to a 3 percent to 10 percent increase in VMT. These results do not take into account additional travel that might be generated by new development that occurs in response to the new highway capacity. The authors conclude: "The research evidence on induced travel effects clearly shows that behavioural responses are real and can have significant impacts on the congestion reduction benefits of capacity expansion projects" (pg. 23).

However, a new article by Mokhtarian, et al. (2002) appears to refute the earlier studies. This study took a more disaggregate approach that matched 18 highway segments in California whose capacities had been expanded with similar segments whose capacities had not been expanded. The data set consisted of average daily traffic (a count of the number of vehicles passing a particular point) and design-hour-traffic-to-capacity ratio (a measure of congestion) for each of twenty years for each of the expanded segments and their matched pairs. Three different statistical approaches used to test for a difference in ADT and DTC between expanded and unexpanded segments consistently showed no statistically significant difference and thus "no evidence of induced demand." However, the researchers suggest several factors that might explain the apparent discrepancy between their results and those of earlier studies: regional differences in the induced effect, a stronger induced effect on VMT rather than ADT, the possibility that the true

effect lies somewhere between zero and the results of earlier studies that may have overestimated the effect, and the fact that the matched-pairs approach looked for an effect only on a selected set of segments rather than on the entire roadway system. However, additional evidence seems to be coming in that also suggests that the induced travel effect is limited. Choo, Mokhtarian, and Salomon (2001) developed a national-level model of VMT growth as a function of a variety of factors but found that the coefficient for highway capacity was not statistically significant. Using a path model that sorted out the causal links between freeway investments and traffic increases and that focused on operating conditions rather than amount of pavement, Cervero has reportedly found elasticities considerably lower than those found in previous studies (IURD 2002).

The debate will most likely continue as new data sets and more sophisticated statistical techniques are used to test for a relationship between the expansion of highway capacity and increases in the amount of driving. The induced travel effect seems to be real, though it may be quite small. The degree to which increases in highway capacity have themselves contributed to the growth in VMT or simply helped to accommodate the relentless growth in VMT driven by rising incomes, changing lifestyle patterns, or other factors remains to be proved. What is beyond doubt is that VMT has grown faster than highway capacity, population, the economy, or just about any other possible causal factor. Thus, the converse of this assumption is almost certainly not true: not building new highways will not appreciably slow the growth in vehicle travel, at least not until congestion levels increase significantly.

Proposition 3: Investing in light rail transit systems will increase densities



Investments in transit and especially in light rail transit (LRT) systems play an important role in smart growth strategies. Not only will such investments increase the use of transit and encourage a shift from driving to transit, they will help to increase the density of development and thus serve as a counterforce to continued sprawl, according to proponents. A pro-light rail group in Austin argues that "…LRT strengthens existing neighborhoods while attracting clusters of development around transit stations in more lightly developed areas… LRT is a powerful tool to deal with urban sprawl" (Light Rail Now 2002). Transit agencies throughout the US are working to promote transit-oriented development (TOD) in station areas, and the Federal Transit Administration gives credit for policies to encourage transit-supportive development in its assessment of funding

requests for new rail systems (FTA 2002). Most proponents recognize that LRT on its own won't promote TOD, but believe that it can be a powerful force for shaping land development patterns in metropolitan areas when combined with appropriate policies and some public assistance.

Transit systems potentially impact development in two ways, just as highways do: by reducing transportation costs and by changing relative accessibilities. First, if a transit system reduces travel times, it may enable residents to live farther out, thereby increasing rather than decreasing sprawl. In addition, by reducing transportation costs, a transit system might increase overall development in the region, leading to a net gain for the region (though probably at the expense of some other region) – a "generative" impact. However, most new light rail systems are designed to serve areas of existing development and may have little impact on travel times. Second, through its impact on accessibility, a transit system might influence where in the region development occurs, focusing development in particular corridors and around station areas, for example; this effect means a redistribution of development rather than a net gain. This effect can help to increase ridership and may serve as a catalyst for redevelopment in selected areas. Theory thus suggests that transit systems may have conflicting effects on development patterns, encouraging sprawl in some ways and acting as a counterforce to sprawl in others. In determining the net effect of transit, it is difficult to separate out the effect of transit from the other forces influencing the amount and location of development in a region. Since it is impossible to know what development would have happened without the transit system, it is impossible to know for certain what difference the transit system made. Despite this challenge, the impacts on development of transit systems, particularly rail rapid transit systems and light rail systems, have been evaluated and summarized by a number of researchers.

On the first point, the available research provides no support for the assumption that transit will lead to a net gain in development for a region. A 1977 report by Knight and Trygg concluded that transit systems do not generate "inter-regional transfers," thereby increasing the overall development within the region, although the evidence on this issue was scant (Knight and Trygg 1977). In other words, there was no evidence that regions that invest in new transit systems grow faster than they would have had they not invested in the transit system. This finding was echoed in a 1995 report from the Transit Cooperative Research Program (TCRP), which concluded that "urban rail transit investments rarely 'create' new growth, but more typically redistribute growth that would have taken place without the investment."

On the second point, the evidence shows that transit can and often does influence where in the region growth occurs, but only given the right conditions and policies. The Knight and Trygg report explored the importance of four different factors in influencing the impact of transit on land use: local government land use policies, regional development trends and forces, availability of developable land, and the physical characteristics of the area (Knight and Trygg 1977). They concluded that:

- "…local government policies are important factors affecting development, with transit being an important but not sufficient condition for such development." Policies such as liberal floor-area ratios, density bonuses, changes in zoning, marking of air rights, and sale of excess land parcels can all help to encourage development around the transit system.

- "When the general character of the area is favorable toward development… transit may further enhance such development." Development is most likely in locations where some development would have occurred even without the transit system.

- "Market forces - primarily the availability of land for development - may significantly affect the location and degree of development above and beyond other influences…" The availability of "suitable, assemblable land" is an obvious prerequisite for development.

- "… physical characteristics of the area to be served are important factors in determining transit's potential land use impacts." Development was less likely along existing rail lines, in freeway rights-of-way, and in industrial areas.

Another important issue raised in this study is the timing of land use impacts: "substantial land use impacts do not occur until several years after inauguration of transit service" (Knight and Trygg 1977). In other words, transit operators cannot count on the ridership or other benefits of station-area development in the early years of the system. The report concluded on the sobering note that transit operators cannot always count on station-area development ever happening: "It seems from the evidence available that rapid transit improvements can provide an impetus toward generation of new nearby development. However, transit alone seems no longer enough to insure such development, in this day of very high accessibility often only marginally improved by the transit system" (pg. 245).

Every study since then has reached almost the same conclusion. A widely-cited study by Cervero in 1984 was somewhat more optimistic about the potential for light rail transit to influence development but still cautionary (Cervero 1984). This study reviewed the experiences of 12 cities with light rail systems and concluded that "a strong and growing regional economy is an important prerequisite" for station area development. The study also concluded that "the developability of land and a suitable physical setting around LRT stations are important conditions for positive land use changes," an issue that arises when alignments were chosen to minimize construction costs rather than maximize development potential. Another related lesson is that "the strongest development potential of LRT is in downtown areas," especially when coupled with policies such as restrictions on parking supply and the use of density bonuses as a part of an overall redevelopment effort. This study concludes that "LRT can be an important, though unlikely a sufficient, factor in changing land use" (pg. 46).

A more recent review of these studies and others concludes that "almost exclusively, transit system's impacts on land use are limited to rapidly growing regions with a healthy underlying demand for high-density development" (Vesalli 1996). In addition, this study

found that public sector involvement (including land assembly, high-density zoning allowances, restrictions on parking, and financial incentives) played an important role in most successful examples of development around transit stations. The study concludes that such policies are a necessary condition for development and that "these land use impacts of transit are not accidental, nor automatic… the only substantial impacts of transit on land use are those that have been planned, and this planning entails a substantial investment of public sector resources and coordination" (Vesalli 1996: 99).

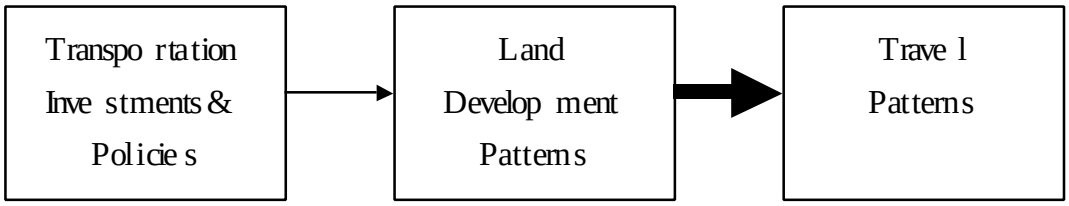
The 1995 report from the TCRP comes to a similar conclusion: "transit investments and services are incapable by themselves of bringing about significant and lasting land-use and urban form changes without public policies that leverage these investments and the pressure of such forces as a rapidly expanding regional economy" (pg. 5). In comparing the impacts on land use of different kinds of transit systems, the report reaches another important conclusion: the impacts of light rail, busways, and conventional bus transit "have generally been weaker than those of heavy rail systems because the systems usually confer less accessibility advantages" (pg. 5). Thus, it seems that a transit system is likely to trigger changes in land use only if it adds significantly to the accessibility already provided by the roadway system. Because most transit systems have the greatest impact on accessibility to downtown, rather than to other areas of the region, the greatest impacts on development have been seen in downtown areas: "within downtowns, rail transit investments have stimulated redevelopment and brought life to once moribund commercial districts" (pg. 15).

Together, these studies provide several important lessons on the role of transit in shaping development patterns:

- A new transit system is unlikely to produce a net gain in development for the region.
- Significant development in station areas is unlikely in regions that are not growing rapidly.
- Public sector involvement is an essential ingredient in station area development.
- Development potential depends on the existing land uses in and around the station site, with downtown areas offering more potential than industrial areas.
- Development potential depends on the nature of the transit system and the degree to which it enhances accessibility in the region.

Thus, the potential for LRT to encourage higher densities depends on the pace of growth in the region, existing land uses in station areas, the nature of the transit system, and public sector involvement. Without the right ingredients, increased densities are unlikely. Even with the right ingredients, increased densities are not assured.

Proposition 4: Adopting New Urbanism design strategies will reduce automobile use



Another assumption of the smart growth movement is that land use and design strategies, such as those proffered by the Congress for the New Urbanism (CNU), will reduce automobile use and create more livable communities. Authors identified with the New Urbanism have articulated specific design characteristics to achieve this goal and claim that by putting the activities of daily living within walking distance and providing an interconnected network of streets, sidewalks, and paths, walking will increase and driving will decrease (e.g. Duany and Plater-Zyberk 1991; Calthorpe 1993; Katz 1994). One of the primary tenets of the New Urbanism is the idea that "communities should be designed for the pedestrian and transit as well as the car" (CNU 2002). The Charter of the New Urbanism states that "Many activities of daily living should occur within walking distance.... Interconnected networks of streets should be designed to encourage walking, reduce the number and length of automobile trips, and conserve energy" (CNU 2002).

Mitchell and Rapkin may have been the first to articulate the connection between land use patterns and travel behavior in their 1954 book *Urban Traffic: A Function of Land Use*. This connection was built into travel demand forecasting models, first developed in the 1950s and designed to predict travel demand as a function of the distribution of population and employment. The theoretical basis for studying this connection has evolved considerably since then. The application of a discrete choice framework for understanding of travel behavior was first articulated by Domencich and McFadden (1975) and later by Ben-Akiva and Lerman (1985) and Train (1986). In this framework, the travel choices made, such as the choice of mode or destination, are determined by the characteristics of the choices available. Each possible choice offers a certain "utility" or value to the individual, who seeks to maximize her utility. Maximizing utility generally means minimizing travel time, but other factors can outweigh time. For example, the greater attractiveness of a more distant destination can lure travelers there, or the value of the exercise one gets while walking can compensate for the longer time it takes. Theory thus points to mixed effects on travel for new urbanism strategies.

The idea that land use and design policies could be used to influence travel behavior was not widely explored until the 1980s. Early interest focused on the connection between density and transit use. The 1977 study by Pushkarev and Zupan is often taken to suggest that transit use can be increased through polices that increase densities. A heated debated ensued in the early 1990s over analysis by Newman and Kenworthy's of the correlation

between densities and gasoline consumption for a sample of international cities (Newman and Kenworthy 1999). In response to the emergence of the new urbanism movement, more recent studies have taken on the broader question of the link between travel behavior and characteristics of the built environment more generally and have set out to test the hypothesis that policies that shape the built environment can be used to reduce automobile travel. Since the early 1990s, studies of the link between the built environment and travel behavior have appeared in the literature with increasing frequency. Recent literature reviews document over 70 studies published during the 1990s that have explored and quantified these relationships (e.g. Handy 1996; Boarnet and Crane 2001a; Ewing and Cervero 2001).

These studies fall into three general categories: simulation studies, aggregate studies, and disaggregate studies (Handy, et al. 2002). Simulation studies use travel demand forecasting models to estimate the impacts of changes in the built environment on travel behavior. This approach has been most often used to test the impact of the design of the street network on VMT (e.g. Kulsah, et al. 1990; McNally and Ryan 1993). Aggregate studies use data on average travel characteristics in zones or tracts (or sometimes cities or regions) to test for correlations between travel patterns and characteristics of the built environment such as density or era of development (e.g. Cervero and Gorham 1995; Friedman, et al. 1992). Disaggregate studies use individual or household-level data to model the relationships between characteristics of the built environment and travel behavior. Most of these studies have focused on the frequency of trips or amount of travel by different modes (e.g. Cervero and Kockelman 1997; Boarnet and Crane 2001b; Handy and Clifton 2001). Cutting across these three categories are differences in the travel characteristic used as the dependent variable (e.g. VMT, trip frequency, trip length, mode choice) and the characteristics of the built environment used as independent variables (e.g. density, era of development, network characteristics, access to jobs or shopping, etc.). Most studies have focused on travel in general, while some studies have distinguished between work travel and nonwork travel.

One of the challenges in these studies has been to sort out the relative importance of socio-economic characteristics and characteristics of the built environment in explaining travel behavior. Ewing and Cervero (2002), after one of the most thorough reviews of these studies, come to several important conclusions:

- Trip frequencies appear to be primarily a function of the socio-economic characteristics of travelers and secondarily a function of the built environment.

- Trip lengths are primarily a function of the built environment and secondarily a function of socioeconomic characteristics.

- Mode choices depend on both socio-economic characteristics and characteristics of the built environment, though probably more the former.

- Characteristics of the built environment are much more significant predictors of VMT, which is the outcome of the combination of trip lengths, trip frequencies, and mode split.

In a form of meta-analysis, Ewing and Cervero (2002) estimated elasticities for VMT and vehicle trips based on the results of all available studies as well as original data analysis for available data sets. Four measures of the built environment were used: "density," measured as population plus jobs divided by land area, "diversity," a measure of jobs-population balance; "design", a combination of sidewalk completeness, route directness and street network density; and "regional accessibility," an index derived with a gravity model. These estimates were both point elasticities, calculated at the average value of the variable, and partial elasticities, which control for the effects of other variables. The results showed a statistically significant but rather limited link between characteristics of the built environment and travel behavior (Table 1). A 10% increase in local density, for example, is associated with only a 0.5% decline in vehicle trips and VMT. The highest elasticity was for regional accessibility (a 10% increase in regional accessibility was associated with a 2% decline in VMT), but regional accessibility is also arguably the most difficult characteristic to modify.

Table 1. Typical Elasticities of Travel with Respect to the Built Environment

	Vehicle Trips	VMT
Local Density	-0.05	-0.05
Local Diversity	-0.03	-0.05
Local Design	-0.05	-0.03
Regional Accessibility	--	-0.20

Source: Ewing and Cervero 2002

The debate that remains has to do with the issue of causality. Almost all of the available studies have used a cross-sectional design that compares travel behavior for different people or places at one point in time. These studies thus reveal correlations between the built environment and travel behavior but do not prove causality. In other words, it is not possible to say that a 10% increase in local density in a particular neighborhood will lead to a 0.5% decline in vehicle trips and VMT. This issue is often discussed by researchers in terms of "self-selection," the possibility that individuals who would rather walk or take transit than drive choose to live in neighborhoods conducive to walking and taking transit. In other words, the characteristics of the built environment did not cause them to

drive less, rather their desire to drive less caused them to select a neighborhood with those characteristics – the reverse of the presumed causality. As a result, it is not possible to predict the impact on travel of either increasing the density in a particular neighborhood or of moving residents from one kind of neighborhood to another.

A few researchers have made some effort to address the self-selection issue. Handy and Clifton (2001) found both quantitative and qualitative evidence that residents of an Austin neighborhood where the average frequency of walking to the store is significantly higher than in other neighborhoods did in fact choose that neighborhood because they like to walk to the store. In the first longitudinal study of the link between the built environment and travel behavior, Krizek (forthcoming) used the Puget Sound Panel Survey to explore changes in travel behavior when residents move from one type of neighborhood to another. He concludes that "households change travel behavior when exposed to different urban forms. In particular, locating to areas with higher neighborhood access decreases vehicle miles traveled." However, this study did not address the motivations behind the move or the attitudes of residents towards driving that might also explain their behavior. It does show that residents who choose to live in higher access neighborhoods (which are generally more conducive to walking and transit) do drive less when given the opportunity. Indeed, the importance of attitudes in explaining travel behavior has not been given the emphasis it needs in these studies. Only Kitamura, et al. (1997) have taken on this issue in a substantial way, and they found that attitudes where a more significant predictor of travel behavior than either socio-economic characteristics or the built environment. Based on these results, it is safe to conclude that land use and design strategies such as those proposed by the new urbanists may reduce automobile use a small amount, depending in part on whether such strategies simply enable desired travel behavior or whether they cause a more fundamental change in travel behavior.

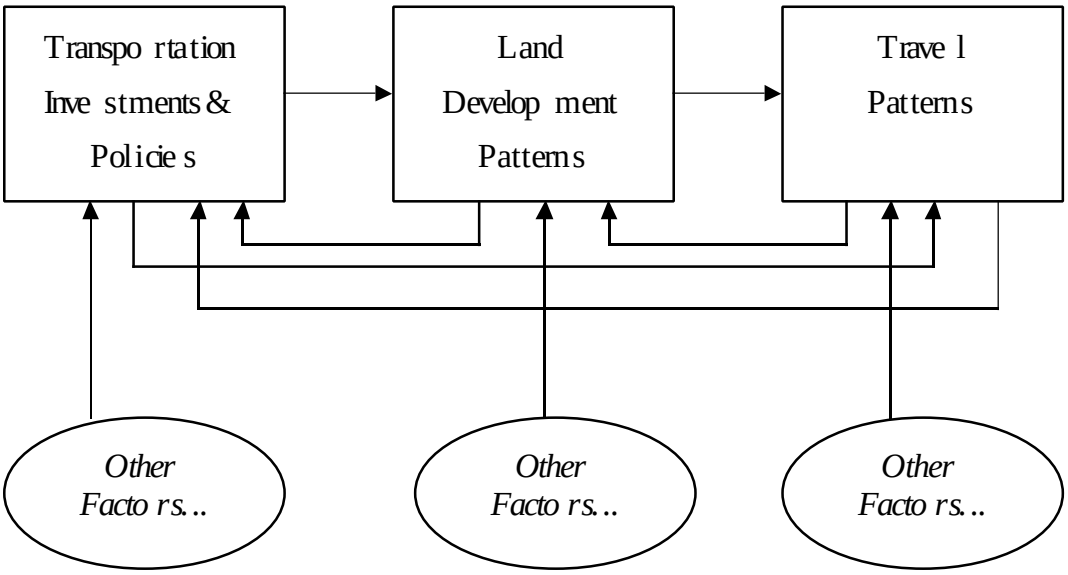
Conclusions

Here's what can be concluded from the available research about these four common assumptions about the transportation – land use connection and its role in smart growth efforts:

- New highway capacity will influence where growth occurs.
- New highway capacity might increase travel a little.
- Light-rail transit can encourage higher densities under certain conditions.
- New urbanism strategies make it easier for those who want to drive less to do so.

The assumptions have not been fully resolved by the research to date for a variety of reasons. For one thing, the connections between transportation and land use are much more complicated than they at first seem. Rather than a simple linear relationship

between transportation investments, land development patterns, and travel patterns, we face a system of endogenous relationships between transportation and land use: the influence of land use patterns on decisions about transportation investments, the impact of traffic on location decisions, and so on. In addition, countless exogenous factors also come into play. For another thing, the data available to sort out these complex relationships are simply not up to the challenge, although they are getting better. Researchers are increasingly employing sophisticated statistical techniques to compensate for the poor data and to account for endogenous relationships. Undoubtedly, researchers will continue to make progress. In the meantime, questions remain for all of these assumptions about the degree of the connection and the direction of causality. As long as these questions remain, reliable predictions of the impacts of new transportation investments on land development patterns or of land use and design strategies on travel behavior will themselves remain elusive. Until such answers are available, proponents of smart growth may want to move the debate away from a war of numbers over sprawl and vehicle-miles-traveled and towards a discussion of the clear benefits of smart growth: expanded choices and improved quality of life.



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