POLICY BRIEF

Regional Accessibility

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Project Description

This project reviews and summarizes empirical evidence for a selection of transportation and land use policies, infrastructure investments, demand management programs, and pricing policies for reducing vehicle miles traveled (VMT) and greenhouse gas (GHG) emissions. The project explicitly considers social equity (fairness that accounts for differences in opportunity) and justice (equity of social systems) for the strategies and their outcomes. Each brief identifies the best available evidence in the peer-reviewed academic literature and has detailed discussions of study selection and methodological issues.

VMT and GHG emissions reduction is shown by effect size, defined as the amount of change in VMT (or other measures of travel behavior) per unit of the strategy, e.g., a unit increase in density. Effect sizes can be used to predict the outcome of a proposed policy or strategy. They can be in absolute terms (e.g., VMT reduced), but are more commonly in relative terms (e.g., percent VMT reduced). Relative effect sizes are often reported as the percent change in the outcome divided by the percent change in the strategy, also called an elasticity.

Summary

Strategy Description

Regional accessibility describes the ease with which destinations can be reached throughout an urban region. The proximity of trip origins, residences in particular, to potential destinations such as jobs or shops, and the nature of the transportation links between them, together determine accessibility.

Accessibility can be evaluated at multiple geographic scales and for multiple purposes, but research on regional accessibility commonly focuses on commute travel by automobile or transit, the two modes most strongly associated with longer distance travel within urban areas. The most basic common measure employed for analysis is the distance from a residence to the nearest central business district (CBD). Another common measure is to count the potential destinations (typically jobs) located within a certain distance or travel time from a residence, sometimes using an impedance factor to discount for destinations at further distances.

For any given residence, accessibility will vary by type of activity (e.g., jobs, hospitals, shops, leisure, etc.) and mode and time of travel (e.g., driving versus transit, during on- or off-peak periods). Accessibility is also influenced by preferences and constraints, such as work schedules, and physical or safety barriers with varying effects for different population groups.

The impact of regional accessibility on VMT reflects the interaction of various transportation and land use factors operating at multiple geographic scales. Accessibility can be enhanced

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with greater location proximity (more origins and destinations located closer together), even when travel speeds are low. As traffic congestion has worsened and environmental concerns about consequences of auto-dependency have risen, greater attention is being paid to benefits of proximity found in denser, more compactly developed neighborhoods and urban areas, and facilitation of more energy-efficient, if slower, transportation modes including transit, ridesharing services (such as bikeshare), and walking and biking.

For longer trips, carpooling and transit are currently the main modes that can potentially compete with single-occupant vehicle trips. Traditional transportation planning has focused heavily on improving mobility (speed), mainly for auto traffic, and all else equal, a mobility improvement also enhances accessibility. But over time, measures such as roadway widening meant to enhance automobility have increasingly been recognized as inducing more, not less, traffic congestion, by inducing lower-density development, putting more cars on the road, and inhibiting other modes (Levine et al., 2019). While more compact development may be associated with lower auto traffic speeds, accessibility benefits of proximity often outweigh costs of speed reduction, favoring overall accessibility (Mondschein and Taylor, 2017; Levine et al., 2019). Research indicates that more compactly built regions also offer greater auto accessibility, on average (Levine et al., 2019).

Location proximity is especially critical for transit to succeed, as compact, mixed-use, and walkable neighborhoods (features characterizing “transit-oriented development,” or TOD) are associated with higher transit use. For transit, regional and sub-regional accessibility are highly linked to local accessibility, in that more proximate origins and destinations can enhance both. Transit usage increases when both trip origins and destinations are located near transit stops, meaning that compact mixed-used, walkable development patterns in multiple station areas can facilitate more ridership. (See the policy briefs in this series on Transit-oriented Development and Land Use Mix for further discussion).

Transit can be considered essential for facilitating regional accessibility that reduces VMT, compared to other modes, because of its potential to support efficient longer-distance travel in built-up areas, and also because of the strong association observed across regions between transit service levels provided and associated land uses that facilitate not just transit use but also more walking, biking, and shorter car trips (Levine et al., 2019; Gallivan et al., 2015). TOD fosters transit ridership and service improvements that can in turn foster new infill development in a “virtuous cycle.” Research confirming the interplay over time between transit and land use at a regional scale, in fostering VMT reduction, includes studies that find that higher urban-area transit supply correlates with more compact development, and that consequent joint impacts on VMT can be attributed primarily to the land use side of the equation (Lee and Lee, 2020; Ewing et al., 2015; Sabouri et al., 2024). These findings point to the importance of coordinating long-term and wider-than-local TOD-transit strategies.

Behavioral Effect Size

Research on the impact of built-environment (BE) factors upon travel behavior has generally examined effects, including for regional accessibility, measured for residents of specific local areas. The research has found that regional accessibility exerts a significant effect on vehicle miles traveled (VMT), with an average elasticity across multiple studies for access to jobs of -0.20 (Ewing and Cervero, 2010; Stevens, 2017). This effect is greater than the influence of other local-scale BE factors typically examined in the research, including development density, mix of land uses, and walkability.

Co-benefits and Synergies

Because of the importance of transit in facilitating regional accessibility that reduces VMT, synergistic strategies to support TOD-transit connections are vital. A variety of strategies can help. Pricing policies, such as for parking, coupled with transportation demand management strategies, such as employer-provided transit subsidies, can help reduce auto-dependency for TOD residents. Funding can be increased for transit service improvements and for shared mobility modes and strategies to address "first mile-last mile" needs for transit users. Additionally, zoning, permitting, and financing strategies to promote compact mixed-use development, reduce parking requirements, and provide affordable housing near transit can help make TOD more viable and equitable.

Synergy is also possible with pricing strategies for roadways, such as road user charges, that incorporate more of the external costs of driving into the price, and which can provide funds for transit as well as ridesharing services and active transport facilities (for biking and walking).

Equity Considerations

Many equity advocates contend that accessibility should be the proper focus for equitable transportation policymaking, given its importance for satisfying basic needs. Strategies to support equitable TOD, such as by constructing and protecting affordable housing near transit, and designing for safe and convenient access, can help ensure that transit is available to low-income, non-white, and disabled individuals, who tend to rely on transit more than others.

Although results vary by metropolitan area, multiple studies indicate that low-income and non-white households do not, on average, tend to experience lower regional accessibility traceable to residential location more than other households, despite their lower levels of car ownership (Martens et al., 2022). This pattern reflects historic policies and conditions, such as exclusionary zoning in many suburban areas, that have worked to ensure that low-income and minority households are more likely to live in central areas and inner-ring suburbs, which generally have higher regional accessibility than other areas.

Some scholars contend, however, that equity analysis, such as described above, which considers only average impacts across social groups or communities, is inadequate. A redistributive justice approach could instead focus on identifying and providing adequate levels of regional transit accessibility to transit-dependent households.

Strategy Description

Regional accessibility describes the ease with which destinations can be reached throughout a region. The proximity of a residence to potential destinations, such as jobs, hospitals, shopping, and leisure-time activities, and the nature of the transportation links between those trip origins and destinations, together determine accessibility. In general, the closer a residence is to the center of the region, the higher the level of regional accessibility, given the typical concentration of jobs and other activities in the center. Close proximity to secondary centers of activity – "subcenters" – also affects regional accessibility.

For any given residence, accessibility will vary by type of activity (e.g., going to work or to shop), mode of travel (e.g., driving versus transit), and time of day. For individuals, accessibility is also influenced by preferences and constraints, such as time-of-day constraints reflecting work schedules, and physical or safety barriers with varying effects for different population groups. In addition to assessing accessibility from the viewpoint of residences considered as trip origins, it can also be viewed from the perspective of trip destinations, such as job centers and shopping malls, to their prospective labor force or customers; some recent research aims to explicitly account for both sides of the origin-destination supply-demand balance.

Strategy Effect

The impact of regional accessibility on travel is not straightforward. Higher accessibility can result in shorter travel distances because destinations are closer. On the other hand, higher accessibility can also mean more frequent trips, particularly for shopping and other non-work purposes, because residents have more choices among nearby destinations (Handy 1996).

Accessibility can be evaluated at multiple geographic scales and for multiple purposes, but research on regional accessibility commonly focuses on commute travel by automobile or transit, the two modes most strongly associated with longer distance travel within urban areas. The most basic common measure employed for analysis is the distance from a residence to the central business district (CBD). If straight-line distance rather than network distance is used in this measure, it reflects only land use patterns and not the transportation network.

Distance-to-CBD is not considered an optimal measure of regional accessibility, given the polycentricity and dispersed development patterns in many metropolitan regions. A second very common type of measure incorporates both land use patterns and the transportation network, in one of two ways. The simpler approach is to count the number of potential destinations (e.g., stores or jobs) within a certain distance or travel time from the residence (called a "cumulative opportunities" measure). A somewhat more complicated approach is to weight destinations by distance, with closer destinations contributing more to regional accessibility than more distant ones (called a "gravity" measure).

The most common measure of regional accessibility examined in research is access to jobs, sometimes broken down by occupation or industry, because job data is more readily available by location than information distinguishing destinations by type (e.g., numbers and locations of health care centers, parks, shops, and offices in a given locale). Job access is often considered to be a reasonable proxy for measuring access to multiple destination types, because they all presumably tend to hire workers (e.g., for jobs at shops, office buildings, or public facilities). While the cost of accessibility (impedance) is often measured in terms of travel distance (e.g., by counting the number of jobs accessible within x miles), many recent studies also consider travel time (e.g., measuring the number of jobs reachable from home within 30 minutes by car and 45 minutes by transit).

Simple cumulative measures of this sort have been criticized for being arbitrary, for example in establishing the cut-off ("boundary") points (why measure jobs within 30 minutes and not 32 minutes?) (Handy & Niemeier, 1997). But some research indicates that if boundary points are established carefully to match the average observed travel times in given areas, then results from simple cumulative opportunities measures correlate highly with results obtained using gravity measures (El-Geneidy and Levison, 2006; McCahill et al., 2020; Palacios et al., 2022; Kapatsila et al., 2023). Recent studies also often test a range of cut-off points to compare findings, thereby approximating a test of observable impedance.

The net impact of regional accessibility on VMT reflects a combination of transportation and land use factors operating and interacting at multiple geographic scales. Accessibility depends on proximity of origins and destinations as well as means of reaching them, implicitly accounting for both land use patterns and transport facilities and service levels (including virtual mechanisms).

All else being equal, an improvement in travel speed (mobility) also improves accessibility, helping explain why transportation policy for decades has emphasized roadway investment, which in turn has facilitated low-density, car-dependent development patterns. The result is that accessibility by automobile is generally much higher than accessibility by other modes in US urban areas overall.

But over time, measures such as roadway widening meant to enhance automobility have increasingly been recognized as inducing more, not less, traffic congestion, by inducing lower-density development, putting more cars on the road, and inhibiting other modes (Levine et al., 2019). Worsening traffic congestion, along with environmental concerns, have prompted greater recognition of the negative consequences of auto-dependency and drawn greater attention to benefits of location proximity and use of more energy-efficient modes, including transit, shared mobility services, walking, biking, and telecommuting.

Accessibility can be enhanced with greater location proximity, even if travel speeds are slower (such as when someone walks to get groceries, rather than driving) (Levine et al., 2019). While more compact development may be associated with lower auto traffic speeds, accessibility benefits of proximity often outweigh costs of speed reduction, favoring overall accessibility (Mondschein and Taylor, 2017; Levine et al., 2019). Research indicates that more compactly built regions also offer greater auto accessibility, on average (Levine et al., 2019).

Location proximity is especially critical for transit success, as compact, mixed-use, and walkable neighborhoods (a.k.a. TOD zones) are associated with higher transit use. Transit usage is found to increase when both trip origins and destinations are located near transit stops, meaning that compact mixed-used development in multiple station areas can facilitate more ridership (Suzuki and Cervero, 2013; Nasri and Zhang, 2019; Cui et al., 2022; Wu et al., 2023). Transit ridership increases with greater regional network accessibility of transit systems (Renne et al., 2016).

The association between accessibility and density (proximity) points to a question about whether regional accessibility by auto is enhanced when jobs are centered rather than being dispersed. One study that examined this question by Boarnet and Wang (2019) identified 46 employment sub-centers in the Los Angeles area and calculated access to jobs within and beyond those sub-centers. Access to jobs outside sub-centers was found to have the largest elasticity in relation to VMT (− 0.155). Places in the top quintile of access to non-centered jobs were found to be often located in inner ring suburban areas not far from sub-centers, suggesting to the authors that infill strategies in those locations might be an effective approach to reducing VMT.

Although research indicates that policymakers and planners increasingly recognize the appropriateness and value of considering accessibility, rather than mobility, as the primary objective for transportation policy, the concept has been welcomed more in theory than practice (Proffitt et al., 2019; Levine et al., 2019; Handy, 2020; Siddiq and Taylor, 2021). Many practitioners find accessibility analysis more challenging than mobility analysis, which employs well-worn standardized techniques for measuring traffic speed and delay. Challenges for broad deployment of accessibility analysis pertain to developing measures and techniques that meaningfully capture the many dimensions of access, have manageable data requirements, and are understandable to planners, public officials, and the public (Siddiq and Taylor, 2021). Another barrier for practitioners is the lack of regulatory frameworks and guidance for using accessibility metrics (McCahill et al., 2020; Handy, 2020).

Behavioral Effect Size

Much research has been conducted aiming to disentangle the impact of built-environment (BE) factors upon travel behavior. Most such studies focus on factors measured at a local rather than regional scale, aiming to determine the effect of neighborhood characteristics such as development density and mix of land use types on travel behavior, measured generally as numbers of trips made, mode(s) chosen, and/or VMT, for area residents.

Two meta-analyses of multiple BE-travel behavior studies of the sort just described (Ewing and Cervero, 2010; Stevens, 2017) point to the importance of regional accessibility for reducing VMT. The meta-analyses determined average elasticities across multiple studies for the effect size on VMT of each of five BE variables commonly studied (the so-called "five D's"). Four of these factors are commonly measured locally (development density, land use mix, street design, and distance to transit stops/stations), and one at a regional or sub-regional scale, namely regional accessibility.[1]

Both these meta-analyses found generally small VMT effects for each of the local-scale BE factors, but they found larger impacts for regional accessibility. The two analyses concur on the average elasticity size observed across studies for job accessibility by auto, at -0.20. In Stevens's results the variable with the largest influence overall on VMT is the distance to downtown, with an elasticity of 0.63, while Ewing/Cervero's elasticity for distance to downtown is smaller (the positive elasticity indicates lower VMT for closer distance).

Table 1 at the end of this report summarizes findings from 13 studies that estimated an elasticity of VMT with respect to regional accessibility. Eight of the studies were included in Stevens' meta-analysis, comprising those he evaluated that included regional accessibility measures, and were conducted in North America since 2000 (excluding unpublished studies). Results from an additional 5 studies, not included in Stevens' work, are also presented in Table 1 (namely, the studies published by: Boarnet et al., 2011; Salon (2015); Zhang and Zhang (2018); Duranton and Turner (2018); and Lee and Lee (2020)).

The studies in Table 1 show a wide range of estimated elasticities, ranging from +0.20 to -0.31 (with the elasticities for distance-to-CBD shown with their sign reversed, for consistency). Most reported values for distance-to-CBD cluster within the range of -0.18 to -0.31, while elasticities found for job access by car are more wide-ranging. The two studies that employed a gravity measure of job accessibility (Frank et al., 2009; Kuzmyak et al., 2006), considered to be a preferable measure compared to simple cumulative opportunities measures, reported elasticities of -0.10 and -0.13. Two studies that examined results for different boundary sizes (Salon, 2015, and Cervero and Duncan, 2006) found the VMT reduction effect to be strongest within a 4-5 mile radius. One study that distinguished trips to work from other trips (Ewing et al., 2015) found an inverse relationship in VMT elasticities when considering results using different travel time boundaries; within a 20-minute cumulative opportunities boundary, the VMT elasticity was much stronger for non-work trips compared to work trips, while the reverse was true when opportunities were measured within a 30-minute boundary. Results from California studies do not seem to vary systematically from results found elsewhere.

The Ewing/Cervero meta-analysis (2010) identified studies that examined the influence on VMT of job access not just by car but also by transit; however, only three of the studies they examined did so. The elasticities reported in these studies ranged from -0.10 to -0.18. Some research has examined the effect of regional accessibility by transit on mode choice, although not on VMT. In a study of 4,400 fixed guideway transit stations across the US, Renne and co-authors (2016) found that regional network accessibility, measured as the share of jobs and population within the region living within the half-mile catchment area for all stations, was the strongest predictor of the share of transit commuting at the station level; a doubling of this variable was associated with a 52% increase in the share of commutes by transit.

Various scholars have argued that transportation-land use relationships should be considered at a

[1] Ewing and Cervero (2010) weighted the reported elasticities for sample size, and Stevens for sampling error. All the included studies controlled for socio-economic characteristics of households and travelers, and some explicitly controlled for self-selection (whereby individuals choose their work or residence location based on BE preferences, meaning that analysis of BE influences could be biased if this preference is not accounted for). Stevens (2017) also controlled for selective reporting bias, a phenomenon affecting whether results are likely to be published.

regional and not just local scale to fully understand how VMT reduction may be associated with sustainable land use characteristics. One study in this vein, conducted by Gallivan and co-authors (2015) for the Transit Cooperative Research Program (TCRP Report 176), found that across more than 300 US urbanized areas in 2010, greater compactness of development was associated with more transit service, with substantial consequences for VMT, and the impact attributed to land use amplified the direct benefits of higher transit service levels by a ratio of 4:1. The additional VMT reductions associated with greater density in transit-rich regions derived from the greater likelihood of using active modes (walking and biking), and making shorter car trips, due to greater proximity of desirable local destinations. Without transit systems to support compact development (and vice versa, based on their coterminous presence), according to the study, gross population densities in the US overall would be 27% lower.

Other studies confirm the importance of considering land use-transportation interactions at the regional scale to understand VMT patterns. Lee and Lee (2020) compared the effects of local land use and urban area (UA) scale spatial structure in a multilevel analysis of the 121 largest UAs in the US. Their results showed that centralized population and meso-scale (ten-mile radius) jobs-housing balance, as well as higher UA population density, significantly reduced VMT and greenhouse gas (carbon) emissions. The combined effects of all UA level variables, including population-weighted density, were found to be on par in terms of VMT impacts with a census tract level compactness index. Furthermore, urban spatial structure was found to moderate local urban form effects. The authors conclude that their findings “strongly support policy measures that aim to boost ‘articulated densities’ in a region…densities that are strategically distributed around urban (sub-) centers and along main mass transit corridors.”

These findings point to the importance of considering and coordinating long-term and wider-than-local interactions between transportation and land use in developing strategies for reducing VMT. Some scholars contend that regional transit accessibility should be considered a “special case” for reducing VMT, due to the importance of transit as an alternative to driving for longer-distance trips, and the nature and implications of long-term co-evolution with land use (Levine et al., 2019). When transit service improvements improve accessibility, they produce so-called “direct” short-term VMT benefits in the form of ridership gains. But over the long-term, and depending on accessibility benefits conveyed, transit can also substantially influence the location and character of development (termed “indirect” effects).

Unfortunately, research is rare investigating regional accessibility impacts delineated by transit mode (e.g., comparing bus, BRT, and rail outcomes), and research to differentiate indirect land use impacts by transit mode is rarer still (Levine et al., 2019). More research of this sort is needed, because land use and associated VMT impacts of transit vary by mode. Some research suggests that rail overall provides greater accessibility benefits than bus travel in the US context (ibid), making it more likely to influence land development, but research also indicates that expanding fixed-guideway (rail) transit to suburban locations may serve to *increase* rather than reduce VMT by prompting more low-density development in outlying areas (Merlin et al., 2021).

By contrast, if accessibility improvements afforded by transit foster more compact, mixed-use and less car-dependent development (i.e., TOD), then the transit improvements can work to reduce VMT even among TOD residents who don’t use transit. This occurs because TOD residents are generally more likely to use active modes (walking and biking), and take shorter car trips, due to greater proximity of desirable local destinations.

The observation that land use effects of transportation projects can vary substantially points to the importance of estimating such impacts prospectively, when considering both roadway and transit improvements. For purposes of reducing VMT, the long-term land use impacts associated with accessibility improvements deriving from transit, as well as from roadways, should be carefully considered.

Co-benefits and Synergies

Because of the importance of transit in facilitating regional accessibility that reduces VMT, synergistic strategies to support TOD-transit connections are vital. A variety of strategies can help. Pricing policies, such as for parking, coupled with transportation demand management strategies, such as employer-provided transit subsidies, can help reduce auto-dependency for TOD residents. Funding can be increased for transit service improvements and for shared mobility modes and strategies to address "first mile-last mile" needs for transit users. Connectivity for active modes can be improved through pedestrian and bicycle network improvements. Additionally, zoning, permitting, and financing strategies to promote compact mixed-use development, reduce parking requirements, and provide affordable housing near transit can help make TOD more viable and equitable.

Synergy is also possible with pricing strategies for roadways, such as road user charges, that incorporate more of the external costs of driving into the price, and which can provide funds for transit as well as ridesharing services and active transport facilities (for biking and walking).

The complementarity of local and regional TOD-transit synergies is supported by research that finds an association between local and regional accessibility levels (e.g., Lee and Lee, 2020). It should be noted, however, that some other studies have found substitution effects rather than complementarity between regional and local accessibility. For example, Handy (1992) and Salon (2015) found that local and regional accessibility were negatively correlated with non-work VMT when included alone in analysis, but the relationships sometimes worked in opposing directions (indicating possible substitution effects) when both were analyzed.

Some scholars contend that TOD strategies are inherently local, obviating regional accessibility planning considerations (Deboosere et al., 2018). Indeed, neighborhood-scale planning is generally overseen by local governments and not state or regional authorities. However, various research studies point to accessibility-driven benefits that can accrue from pursuing transit-TOD coordination at a wider-than-local scale, for example at the scale of transit corridors. Coordinated planning of transportation facilities and services on a corridor and/or travel network basis, for example through signal prioritization for transit, or by introducing transit-only and bicycle lanes along key routes, has been shown to increase transit and active transport use (Suzuki and Cervero, 2013).

To be most effective for mode-shifting and reducing VMT, corridor planning should also address land use; for example, certain metro areas such as Copenhagen and Stockholm have achieved very high transit mode shares through concerted, long-term planning coordination for station areas along transit corridors (ibid). (See the policy brief in this series on Transit-Oriented Development for further discussion.)

If planning coordination for transit and land use is also coupled with strategies to advance social equity, then further co-benefits may be achieved. Low-income and minority households tend to use and rely on transit more than affluent households, so maintaining and increasing affordable housing near high-accessibility transit service can foster equitable TOD ("e-TOD"). As infill and transit-proximate development is increasingly fostered for VMT purposes, affordable housing policies can help ensure that TOD zones accommodate not just mixed land uses but also mixed income residents.

Equity Considerations

Various scholars contend that accessibility analysis is the proper focus for considering equity in transportation, because of the importance for satisfying basic needs of being able to reach essential activities such as employment, health care, and grocery shops (Martens et al., 2022). Accessibility can also enhance mental well-being, inclusion, and life satisfaction in other respects as well.

Although results vary by metropolitan area, multiple studies indicate that low-income and minority households do not, on average, tend to suffer from lower regional accessibility traceable to their residential location compared to other households. Lower-income and minority households enjoy higher accessibility to employment on average, despite their substantially lower levels of car ownership (Martens et al., 2022). This pattern reflects effects of historic policies and conditions, such as exclusionary zoning in many suburban areas, that have worked to ensure that low-income and minority households are more likely than other households to live in central areas and inner-ring suburbs.

But some scholars contend that the sort of analysis characterized by the findings discussed above, which consider only average impacts across social groups or across communities in urban areas, do not go far enough (Martens et al., 2022; Pereira et al., 2017). These authors contend that the goal of addressing redistributive justice implies the need for identifying and addressing transit accessibility deficits in “hot spots,” pockets of land where low regional accessibility afforded by transit coincides with high transit dependency and other indicators of disadvantage (ibid). This confluence of factors can lead to social exclusion, leading these scholars to call for defining and supplying “sufficientarian” or at least minimum adequate levels of regional transit accessibility to transit-dependent households.

As noted, there is potential for achieving synergy and co-benefits for VMT-reducing and equity-enhancing accessibility policies through fostering transit service improvements and housing development in low-income areas served by transit. But on the ground in many cases, TOD policies to foster infill development have encountered opposition from neighborhood residents concerned about losing community character—not just in privileged communities seeking to exclude “undesirable” development (often meaning multi-unit housing development), but also in lower-income communities fearing potential gentrification and displacement in infill areas (TOD zones). Such tensions point to the difficulty that can arise in aligning objectives for TOD policy motivated by environmental concerns (such as for reducing VMT) with concerns about preserving neighborhood character and protecting and preserving housing affordability.

It is beyond the scope of this paper to evaluate research findings on gentrification and displacement threats and VMT impacts stemming from market-rate versus deed-restricted affordable infill and TOD development (but see Chatman et al. (2023) for an in-depth assessment in the California context; also see the policy brief in this series on Transit-Oriented Development, which discusses relevant research in some detail). What is clear, however, is that TOD strategies to improve regional transit accessibility for environmental reasons—such as to reduce VMT—need to be coupled with strategies to identify and address the potential for improving social outcomes for transit-dependent households, such as by protecting and fostering housing affordability near transit.

Confidence

Evidence Quality

The studies in Table 1 use accepted statistical methods to analyze high quality data for individual households. Most were included in Ewing and Cervero’s and/or Stevens meta-analyses, which applied strict criteria for identifying high-quality work, including controlling for socio-economic characteristics of households studied, and, in some cases (as indicated in Table 1), for self-selection (whereby individuals choose their work or residence location based on BE preferences, meaning that analysis of BE influences could be biased if this preference is not accounted for; see footnote 1).

Although they provide the best available evidence of the effect of regional accessibility on VMT in the North American context, the cited studies also have limitations. The estimated effects in all studies are based on a comparison among neighborhoods at one point in time (i.e., a cross-sectional design) rather than assessment of changes in VMT that result from a change in regional accessibility (i.e., a "before-and-after" design).

The lack of consistency in methods and variable measurement specifications across studies hampers comparison. The studies use different measures of accessibility (distance-to-CBD, cumulative opportunities measures, and gravity measures), different boundaries imposed for cumulative opportunities measures (e.g., number of jobs accessible within x number of miles), and different job type specifications. Another major concern is the inconsistency across studies in inclusion and specification of local-scale BE variables, which makes it hard to determine whether the differences in estimated effects across the studies accurately reflect the range of effects present under different conditions (time or place) or merely the differences in variable specification. Table 1 indicates which other locally measured BE variables were controlled for in each study listed. Very few of the studies also included BE variables measured at a wider-than-local scale, with the Lee and Lee study (2020) being an exception. Finally, studies that use data from outside California may not contain findings accurate for California communities.

Table 1. Relationship of VMT and Regional Accessibility

Note: All elasticity values in this table are presented to show effects of greater accessibility. This necessitated reversing signs (to show negative elasticities) for studies in which the measure of accessibility was distance to downtown/CBD, in order to report these findings in a manner consistent with findings from studies in which destination accessibility was measured as access to numbers of jobs (for which in general, reported elasticities are negative, meaning access to higher numbers of jobs is associated with lower VMT).

Study	**Survey data location & year; number of observations; dependent variable**	**Specification of destination accessibility measure**	**Elasticity (Change for 1% Increase in accessibility)**	**Other "D" variables included in study as independent variables, measured locally:**				**Control for self-selection?**
				Density	Diversity	Distance to transit access	Street design	
Boarnet et al., 2004	Portland, OR, 1994; 6,154 observations (obs); non-work daily VMT per person	Distance from household (HH) to Portland city hall (sign reversed)	-0.18	x	x		x	No
Boarnet et al., 2011	LA metro area, 2001-02; 12,029 obs; VMT per HH	a) Distance to city hall; b) tract employment damped by distance to tract centroid	a = 0.20 (sign reversed); b = -0.29	x			x	No
Cervero & Duncan, 2006	SF Bay Area, 2000; 16,503 obs; per person VMT	number of jobs, number of retail and service jobs, within 4 miles	all jobs: -0.31; retail: -0.17[2]					No
Duranton & Turner, 2018	US sample, 2008; 99,875 obs; HH annual vehicle kilometers traveled	Distance to CBD (no definition), sign reversed	-0.02	x				Yes
Ewing et al., 2013	Six US regions, 1991 to 2001; 35,877 trip ends to/from/ within 239 mixed-use dev'ts (MXDs); per person VMT for work/nonwork	number of jobs within 20 and 30 minutes	See footnote[3]		x		x	No

[2]Tested number of jobs matched by occupation of traveler, and number of retail or service jobs (destinations) at various buffer radii. Best results (shown) were within 4 miles. Occupationally matched measure of job accessibility grouped travelers into three basic categories (executive/professional, support/service, and blue collar), with an elasticity of -0.33. Total job accessibility by auto = -0.31; retail job accessibility by auto = -0.17

[3] For number of jobs within 20 minutes for work trips, elasticity = 0.0, for other trips = -0.12; jobs within 30 minutes for work trips = -0.09, for other trips = 0.0

Table 1 (continued). Relationship of VMT and Regional Accessibility

Study	Survey data location & year; number of observations; dependent variable	Specification of destination accessibility measure	Elasticity (Change for 1% Increase in accessibility)	Other "D" variables included in study as independent variables, measured locally: Density	Diversity	Distance to transit access	Street design	Control for self-selection?
Ewing et al., 2015	15 US regions (including Sacramento), 2005 to 2012; 62,011 obs; VMT per HH	% regional jobs accessible by auto within 10 mins, by transit within 30 mins	auto = -0.05; transit = -0.07	x	x		x	No
Frank et al., 2009	King County, Puget Sound, 2006; 2,697 obs; VMT per HH	Accessibility score for transit by TAZ using gravity model	-0.10		x	x	x	No
Lee & Lee, 2020	2009 National Household Travel Survey (NHTS) data for 2009 for the 121 largest urban areas in the US; obs = ?; annual household VMT	Various measures were tested including simple population density, population-weighted density (PWD), and centrality index	−0.11 for PWD, −0.26 for meso-scale jobs-housing balance	x	x	x	x	No
Kuzmyak et al., 2006	Baltimore metro area, 2001; 2,707 obs.; daily weekday VMT per HH	Job accessibility by auto and transit, gravity measure	-0.13		x			No
Nasri & Zhang, 2012	Six US metro areas, 2006 to 2009; 22,904 obs; per person VMT	Distance to city center/CBD for TAZ/tract	-0.24 (sign reversed)	x	x		x	No
Salon, 2015	California, 2000 to 2013; 60,346 obs; weekday nonwork VMT, one-way commute VMT	Local and regional job access (see footnote 4)	See footnote[4]	x	x	x	x	Yes

[4] Local and regional job access = inverse of distance-weighted sum of total jobs available within 5 miles of a tract and between 5 and 50 miles of a tract, respectively. Elasticities: nonwork regional = 0.07, nonwork local = -0.06; commute regional = 0.15, commute local = -0.16

Table 1 (continued). Relationship of VMT and Regional Accessibility

Study	Survey data location & year; number of observations; dependent variable	Specification of destination accessibility measure	Elasticity (Change for 1% Increase in accessibility)	Other "D" variables included in study as independent variables, measured locally:				Control for self-selection?
				Density	Diversity	Distance to transit access	Street design	
Zhang et al., 2012	Six US metro areas, 2006 to 2009; 22,904 obs; per person VMT	Distance to CBD	Baltimore = -0.22; Seattle = -0.27; Virginia = -0.03 ; Wash. DC = -0.30 (signs reversed)	x	x		x	No
Zhang & Zhang, 2018	Austin, TX, 2005–2006; 975 obs; daily per-person VMT	Distance to the nearest activity center defined in regional plan	No pref = -0.07; with pref = -0.27[5] (see note)	x	x		x	Yes

[5] The study employed survey information on residential preference as a control for self-selection distinguishing respondents who indicated residential preference with consideration of access and neighborhood amenities (including safety) (self-selection group) vs. others (non-self-selection group).

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