Spatial Efficiency and Regional Prosperity: A Literature Review and Policy Discussion

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I. Definition and Significance

A successful regional economy depends on the efficient and productive operation of many interacting systems, including labor and housing markets, business investment and supply processes, and other local and regional systems. An important and dynamic intermediate **outcome** from the interaction of these systems is the spatial organization of economic assets *within* a particular region, also known as the urban spatial structure, urban form, or the built environment.

An empirical question remains whether and how the spatial configuration of regional economic assets contributes to economic growth. Theoretically, different spatial configurations could impose differential costs and benefits on regions for conducting economic activity, and thus could have differential impacts on economic growth. The purpose of this section is to inform practitioners regarding what we know and what we do not know about the influence of spatial organization on economic activity and regional prosperity, as well as to discuss what can be done to improve spatial efficiency and what research still needs to be conducted to inform decision-making.

A. What is Spatial Efficiency?

We use the phrase "spatial efficiency" to characterize the ease with which economic activities are geographically organized and transacted within a region. We build upon the traditional notion of efficiency as accomplishing a task with minimal time, effort, or cost. In the case of a regional economy, we are particularly interested in the organization of physical assets, such as buildings, infrastructure, and green space, which structure the transportation, communication, public service, and energy needs of businesses and residents within the region and beyond.

A spatially efficient arrangement should result in less time, effort, or cost for governments, businesses, and households to conduct their daily activities as compared to alternative arrangements. A spatially efficient arrangement should thereby produce stronger economic growth than less efficient arrangements and should provide a competitive cost advantage relative to regions with less efficient spatial arrangements. Alternatively, one could imagine a spatially inefficient arrangement with a poorly organized structure that results in high personal travel and freight transport costs.

The term "spatial efficiency" has its origins in neoclassical economics – the use of land such that the most output possible is produced.[1] The industrial-economics field considers efficiency from the perspective of an individual firm; that the land usage is spatially efficient so long as that firm could not use the land in any other way to increase its output. Classical economists also examine the opportunity costs of the land used in its current capacity, as well as any negative externalities that result from a particular land use (Balakrishnan, Desai, and Storbeck 1994; Louw, Krabben, and Amsterdam 2007). Another strand of economic literature examines the efficiency with which capital or labor is spread across the landscape (e.g., Petchey 2009).

In the public sector context, spatial efficiency has been used as a framework with which to evaluate location decisions of public infrastructure or services (Rasheed 1986; Lall, Schroeder,

[1] The term "spatial efficiency" has been used somewhat differently by other fields. For example, in the environmental fields, the spatially efficient approach to pollution abatement and climate change mitigation is to first remedy the least-cost source of pollution regardless of its spatial location (Petschel-Held et al. 1999). Further, the concept of *location efficiency* has been "defined as the extent to which automobile use can be reduced by land use factors" by urban planners (Goldstein, Holtzclaw, and Litman 2006, 3).

and Schmidt 2009). Fisher and Rushton (1979) are cited as an early example of applying this concept to the public sector, with their analysis of geographic accessibility to health centers in India. The public sector applications of spatial efficiency focus on choosing the locations of public services so as to maximize accessibility and minimize travel times, often using Data Envelopment Analysis to estimate relative values while accounting for different (and often competing) goals, such as minimizing travel times and travel distances (Athanassopoulos and Storbeck 1995; Murray 2003; Thompson et al. 1986).

Our definition of spatial efficiency is similar to these economic uses in that we are concerned with minimizing transaction costs and maximizing output at the level of the regional economy. We are also interested in other economic outcomes besides output, including wage and income growth.

Thus, we define spatial efficiency as: the geographic arrangement of businesses and residences, the physical infrastructure that connects the region (i.e., transportation, communication, green space), and the orientation of each towards the other that minimizes the time, effort, or cost required to conduct economic activities for the entire metropolitan region. We focus on several classes of economic activity, including business-to-business interactions, business-to-worker interactions, and business-to-consumer interactions.

Several implications of our approach are worth mentioning here. First, spatial arrangements are highly dynamic, making the goal of "spatial efficiency" a moving target to a large degree. Second, spatial efficiency is context-dependent, meaning that what is spatially efficient for a particular region at a particular time may vary from what is spatially efficient for another region or at another time. Such variation complicates the study of spatial efficiency, but ultimately allows flexibility in crafting appropriate responses to regional problems and

facilitating economic growth. Third, pursuing a goal of "spatial efficiency" as defined here may involve tradeoffs, such as for quality of life or environmental health. Related, optimizing spatial efficiency to achieve particular ends (i.e., improved business-to-business interactions) may conflict with optimizing spatial efficiency to achieve other ends (i.e., improved business-to-worker interactions).

B. How Does Spatial Efficiency Influence Economic Growth?

A large literature has examined why cities form, and why cities are more productive and command higher wages than alternative spatial arrangements (for a recent review, see Glaeser and Gottleib 2009). Much of this literature focuses on the benefits brought by the agglomeration of economic activity and opportunity within cities, and is largely covered in the section on clusters. Alternatively, a separate literature examines the diseconomies of agglomeration (e.g., traffic congestion, pollution, crime) found in cities that may adversely impact economic growth. For the most part, these literatures treat geography in only a general manner and mostly with respect to city size as a surrogate for agglomeration economies.

Here, we are interested in how the particular spatial configuration of activities within a region, of whatever size, may impact economic growth. Knox (1994) offered a generalized model of urbanization from which we can visualize the macro-relationships (see Figure 1). Knox argued urbanization is driven primarily (but not exclusively) by economic change, which produces spatial outcomes such as land use patterns, built environment, neighborhood composition (here called social ecology), and degree of urbanism.[2] These spatial outcomes then

[2] The term "urban systems" in Knox's model refers to the hierarchical ordering of cities, in which only a few cities rise to global dominance and most other regions remain small and regionally-oriented.

feed back into the economic development process, as well as feed into the policy and planning process.

FIGURE 1. THE URBANIZATION PROCESS (SOURCE: KNOX, 1994)

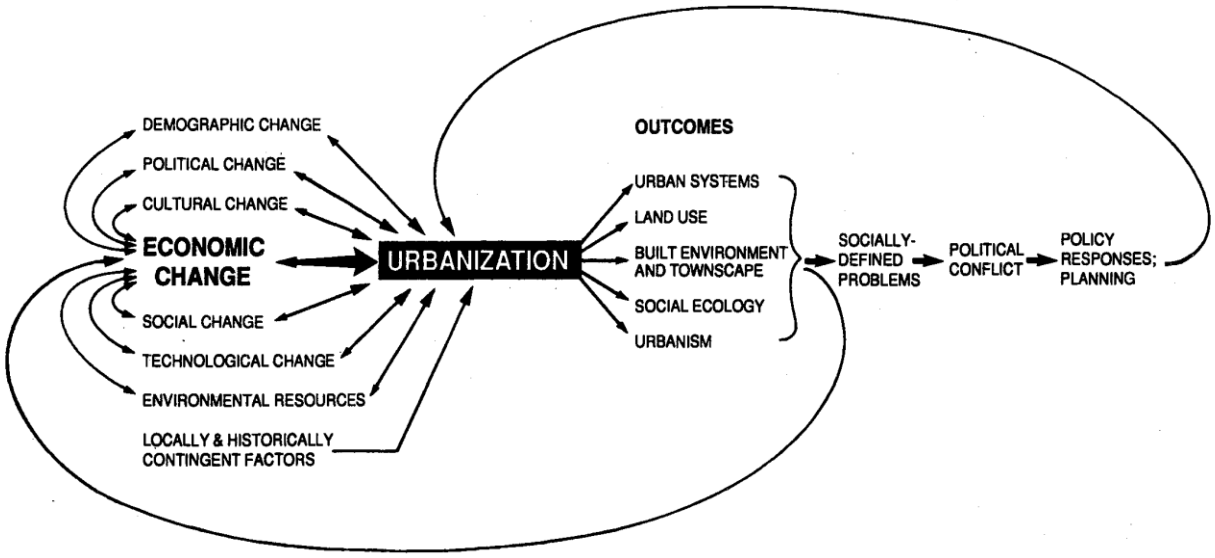


Fig. 1.4 A framework for the study of urban geography: urbanization as a process.

We envision at least two primary pathways through which regional spatial outcomes may feed back into economic development. First, the spatial arrangement of regional resources impacts economic growth through its impact on travel costs for both physical and human capital. Consider:

> "'[A] man who earns $5.00 an hour would consider the time cost of a half-hour trip to be $2.50. This rate of time cost equals the accrual of interest (at 5 percent per annum) on an investment of about $880,000. So, calculated on that basis, human freight carries a time cost equivalent to that of a commodity worth at least $300 an ounce - perhaps not 'more precious than rubies,' but somewhere in the range between gold and diamonds.'" Edgar M. Hoover (1962, 242) (cited by Bogart 2006, 80)

The presumption is that spatially inefficient regions have destinations spread further apart and require residents to drive more to carry-out their daily activities. As a secondary impact, spatially inefficient regions are difficult to service by public transportation networks, forcing persons who might otherwise use public transport into personal vehicles. In both cases, the spatial arrangement of activity may result in longer travel times, which increase the costs of production for firms and decrease available leisure and labor time for individuals and which can constrain economic growth. Alternatively, locating activity near to existing activity—known as co-location—can minimize transportation or communication costs for various interactions and facilitate innovation, knowledge transfer, and the formation of clusters, as discussed elsewhere.

Related, the spatial arrangement of economic assets may reduce economic growth if human capital is located too distant from available job locations, known as a "spatial mismatch." For instance, many regions have experienced a flight of low-skilled jobs, such as those in the manufacturing sector, from the central city. While higher-skilled residents generally have the income to relocate to the suburbs, low-skilled individuals may lack the resources to do so. When these otherwise employable individuals find themselves unemployed, the region experiences a loss of productivity in the form of underutilized human capital, thus reducing economic growth.

Second, because households and businesses are consumers of government services, the location of households and businesses is a major driver of public service costs (including for transportation). In poorly organized areas, public service costs rise, necessitating higher tax burdens for a given level of public goods. These higher tax burdens serve as disincentives for firm location while simultaneously reducing capital and income available for spending within the region.

Other pathways may connect spatial efficiency with economic growth. For instance, besides transportation-related costs there is a separate literature on how urban form relates to building-related energy demands and the efficiency with which energy can be provided to consumers (Anderson, Kanaroglou, and Miller 1996; Ewing and Rong 2008). These energy costs tend to be internalized in location decisions or in private transactions with energy providers, but may pose a barrier to regional economic growth where building energy costs are particularly high. Likewise, the environmental impacts related to transportation and energy use in regions (especially air, water, and land pollution) and from overcrowding may impact public health, deter businesses or workers from locating or staying in the region, and constrain regional economic growth (Mills, Feenberg, and Zisler 1978; Dreier, Mollenkopf, and Swanstrom 2001). The environmental impacts tend to be studied as local diseconomies of agglomeration, and in severe cases can have profound impacts on regional economic growth (Knox 1994).

There is also some concern in the planning and landscape architecture literatures that various aspects of neighborhood design (i.e., density, land use mixing, sidewalks and streetscapes, green infrastructure) may influence the desirability of locating in particular areas and may be related to the attraction and retention of businesses and workers (Ewing 1996). These design elements may also influence property values and drive the accumulation of wealth, which could spur regional economic growth. Alternatively, areas without vibrant, desirable neighborhoods may be slow to achieve their growth potential.

C. What Does the Empirical Evidence Indicate? (Overview)

For the most part, scholars have not directly investigated the impact of spatial efficiency (or related concepts) on regional economic outcomes. One notable exception is Weissbourd (2004), who assessed the relationship between urban form and population growth, income

growth, and wage growth across U.S. metropolitan areas from 1990-2000. Urban form was characterized using several variables including: commute times, density gradients (which were calculated based on Census tract density), discontiguity (measures the dispersion of development), as well as composite measures that account for regional residential density, the accessibility and connectedness of street networks, and the strength of activity centers and downtown areas. Generally, Weissbourd found only minimal relationships between these measures of urban form and regional economic growth; most of the regression coefficients were insignificant and/or substantively small. For example, between 1990 and 2000 commute times were insignificantly related to income and wage growth while public transit and street accessibility were marginally but positively related to income and wage growth *in the city*. Contrary to expectations, density was marginally *negatively* related to income growth in cities.[3] Weissbourd hypothesized that the relationship between economic growth and urban form is nonlinear, with only very sprawled areas experiencing any negative effects. Further, negative effects were more likely to be observed in central cities, than in the region as a whole.

Using a different approach, Persky and Wiewel (2000) assessed the economic costs and benefits of a new manufacturing plant if it located in a suburban greenfield location or in the central city of the Chicago metropolitan area. The authors found that the suburban greenfield location had social costs in the form of externalities and public sector losses that exceed the city location, but that the size of the social cost gap is approximately equal to the private net benefits experienced by the firm that chooses a suburban location. Thus, the net economic benefit of the

[3] Negative relationships between density and income growth in cities may result from urban agglomeration externalities, such as traffic, crime, pollution, and concentrated poverty.

two hypothetical locations is equal, but the suburbanization of manufacturing activities results in a transfer of resources to the private beneficiaries of the suburban plant.

One challenge in quantifying the impact of spatial efficiency on metropolitan growth rates is that much of the existing literature is concerned with the impact of the spatial arrangement of regional activity on central city outcomes. For example, opponents of sprawl argue that this form of economic growth causes employment increases for the region to occur at the expense of the central city. However, this argument does not necessarily imply that the entire region is worse off, only that the central city is worse off. Here, we are concerned with the impact of spatial outcomes on the economic growth of the region as a whole, and for this question, significantly less empirical analysis exists.

Another challenge in quantifying the impact of spatial efficiency on economic outcomes is that spatial efficiency is itself a product of regional economic growth, whether measured by employment, wages, or income. For instance, employment growth necessarily affects the spatial arrangement of resources since the new jobs will have to locate somewhere. Employment growth will require the total land area of the region to expand and/or increase the density of the existing land area, which directly influences the region's spatial efficiency. Wage increases imply employment increases and/or a change in the composition of jobs, thus we would also expect that changes in wages would cause changes in spatial efficiency. If income growth is associated with a residential preference for larger homes, we may observe an inverse relationship between housing density and regional income growth. Such endogeneity is expected if we recall Knox's stylized model (Figure 1), which placed economic change as the predominant driver of urbanization and its subsequent spatial outcomes. Similarly, Persky and Wiewel (2000) argue

that the region's economic growth rate determines its pattern of spatial development, with slower growth regions most likely to experience employment and population deconcentration.

While there is little empirical evidence regarding the direct impact of spatial efficiency on regional economic outcomes, there is a rich literature on the relationships between spatial arrangements and transportation outcomes (especially costs for workers from commuting and spatial mismatch) and public service costs. The following paragraphs summarize the findings. (The reader can find more detailed information about the empirical evidence in Section II.)

First, researchers typically find statistically significant relationships between aspects of spatial structure and transportation costs in the anticipated directions. That is, residents of denser or more compact areas are likely to drive less and incur lower personal transportation costs. These relationships appear to hold for both commuting and non-work travel. The reduced driving effort required in denser and more compact areas indicates those areas are more spatially efficient than their more sprawling or decentralized counterparts.

Second, the research literature suggests that spatially inefficient regions are likely to suffer from spatial mismatches that result in involuntary employment among low-income, uneducated city (predominantly minority) residents. Such a phenomenon appears most likely in larger urban areas and may result from housing segregation by race and income, inadequate public transportation for reverse commuters, and racial discrimination.

Third, the research literature suggests that public expenditures on "hard services" (infrastructure such as local streets, sewerage collection lines, water distribution pipes, storm drainage systems, and local schools) are higher in particularly sprawling regions than they are in more compact urban areas. However, these increased expenditures on hard services are offset by savings on "soft services" (such as education operating expenditures and social services), so it is

unclear whether urban arrangements have a net positive or negative impact on public finances. Further, some of the research shows a "U-shaped" relationship between residential density and expenditures, with public expenditures declining with initial density increases, but then rising after density reaches some threshold (e.g., 250 residents per square mile).

Despite the apparent relationships favoring spatial efficiency, the research literature is divided over the magnitude of impact on transportation and public service costs that can be expected from changing spatial structure. Most simulation-based research suggests a larger impact than has been demonstrated by research on actual travel behavior or public expenditures. Various confounding factors have been suggested that complicate the study of spatial efficiency and may be why there is virtually no research linking spatial efficiency directly to regional economic outcomes.

We conclude that spatial efficiency is likely to be an important factor in structuring regional activity but that behavior is highly dependent on individual and business preferences and other contextual factors about the region, such as its size, age, climate, geography, culture, and governance structures. The onus, then, appears on the individual region to evaluate the extent of its own spatial efficiency and to identify policies and planning efforts that can be taken to improve its spatial efficiency and foster economic prosperity. The following sections review the literature in more detail and then outline the determinants of spatial structure and some ways in which regions might intervene to improve their spatial efficiency.

II. Literature Review on Transportation and Public Service Costs

As described above, we expect that the spatial arrangement of economic assets and activity within a region should influence regional economic prosperity primarily through impacts on transportation costs and public service costs. Further, we expect that transportation and

public service costs and be most directly influenced by efforts oriented around the location decisions or businesses and residents, and the provision of public infrastructure. The following sections begin by reviewing ways in which researchers have measured spatial efficiency, and then reviews for each topic the theory in more detail and the empirical evidence of the relationship.

A. How Do We Measure Spatial Efficiency?

One approach to measuring spatial efficiency is to assess the overall land use pattern within a region, from which we can infer spatial efficiency. A variety of different metrics have been used to measure land use patterns, falling generally into groupings by density, proximity, centrality, and concentration (Cutsinger et al. 2005; Galster et al. 2001).

Density metrics are frequently employed to capture the intensity of development within a region (whether measured by population density, housing density, employment density, or some variation thereof). In principle, regions with higher density (i.e., more persons per unit of land area) may be more spatially efficient, as the distance required to transport people or goods within a region may be shorter and the viability of mass transportation improves in denser areas. Alternatively, denser areas may be subject to more extensive traffic congestion, reducing spatial efficiency. Thus, traditional density metrics are inherently limited in their ability to fully capture the spatial efficiency of a region. Density metrics tend to better capture city size and the phenomenon of urban agglomeration, discussed elsewhere.

Another group of metrics operationalize the *proximity* of different land uses, such as the average proximity or distance of jobs to housing or of housing to retail opportunities. Regions with greater proximity of land uses should be more spatially efficient, as with density, except if the proximity generates extensive congestion externalities. In some cases, researchers examine

measures of the "jobs-housing balance," which reflects the employment opportunities available within a given area (such as a county or a political jurisdiction).

A third group of metrics examine the degree to which a region's activity (i.e., employment, commuting) is oriented around a central city. Regions with single central cities are known as monocentric or mononuclear, and this urban structure serves as the theoretical basis for urban and regional economic theory. Other regions may be organized around more than one city, and are variously considered polycentric, polynuclear, multicentric, or multinuclear. Still other regions may be more fully decentralized with few obvious centers and have been called "beyond polycentric" (Gordon and Richardson 1996). A large debate exists over whether monocentric, polycentric, or dispersed development patterns are most spatially efficient.

Many discussions related to spatial efficiency focus on urban sprawl, which could be a case of spatial inefficiency. As regions grow, they must increase their land area and/or build more densely. Persky and Wiewel (2000) note that in many cases, metropolitan growth is characterized by both expanding land area and by increasing density. In some cases, however, a region experiences declines in central city population or employment accompanied by land area growth (i.e., decreasing density), a trend they refer to as "deconcentration." Many concerns about sprawl are related specifically to deconcentrating areas and where the resulting patterns may be spatially inefficient.

The previous metrics are most frequently calculated at the regional level. Yet, land use within regions may vary considerably. Households, in particular, may be more sensitive to the land use surrounding their homes rather than to the broader regional structure. For this reason, some scholars measure spatial patterns at small-area geographies, such as census tracts or traffic analysis zones (Song and Knaap 2004). In some cases, researchers argue that neighborhood

density serves well enough as a surrogate for other important aspects of the local spatial structure, such as land use mixing and transit accessibility (Bhat and Guo 2007; Brownstone and Golob 2009).

The biggest drawback with using land use metrics to measure spatial efficiency is that we are inferring activity based on spatial structure without much empirical evidence of how people behave in different environments. For this reason, some researchers attempt to directly measure regional efficiency, or at the least, symptoms of regional *inefficiency*. Such measures might include average commute times or distances by travel mode, amount of congested roadways in the region, degree of roadway usage compared to capacity, availability of public transport services, etc. Scholars interested in the local public service implications of spatial efficiency might measure the average response times for fire or ambulance services, for instance. Some economists also compare actual behavior to what might be theoretically optimal given a certain spatial arrangement, such as with "excess commuting" (Horner 2004).

A hybrid approach between measuring pattern and measuring behavior is to examine the *accessibility* of particular locations within a region, which should have a direct bearing on the location decisions of businesses and residents and thereby on their daily activities. Scholars may be interested in specific types of accessibility and sometimes by different travel modes (i.e., by auto vs. by transit or walking). For businesses, scholars may be interested in: (1) access to appropriately-skilled labor, (2) access to suppliers, (3) access to markets, and (4) access to other public services. For residents, scholars may be interested in: (1) access to occupationally-appropriate jobs, (2) access to retail, educational, and recreational opportunities, and (3) access to other public services. Theoretically, firms and residents should face lower costs for

transacting business and conducting daily activities if they locate in areas with high accessibility, except again if such accessible areas suffer from congestion externalities.

Thus, as a complex phenomenon, the choice of appropriate operational measure for spatial efficiency depends in large part on which aspect of spatial efficiency is being studied and at which spatial scale.

B. Transportation Costs (General)

1. Theory

Transportation costs are a critical influence on economic activity. Specifically, transportation costs determine the access of workers to jobs, firms to labor pools, and supplier, buyers, and sellers to the market. Thus, transportation costs represent both production and consumption costs. On the production side, transportation costs occur for firms in the form of obtaining inputs and sending final products to market. To the extent that workers demand higher wages to compensate for their individual travel time and expenses, commuting becomes a cost of the production process. The travel time and expenses that individuals incur in moving to and from retail shopping centers represent costs of consumption and may reduce the price consumers are willing to pay for goods and services accordingly. Thus, from an economic perspective, transportation costs can reduce the number and type of economic transactions that occur by simultaneously increasing the costs of production and reducing the willingness to pay of consumers.

Cities originally evolved as an organizational form to reduce transportation and communication costs from economic activity (Anas and Moses 1978). As Glaeser (1998, 140) argues, "[a]ll of the benefits of cities come ultimately from reduced transport costs for goods, people and ideas." In dense environments, the exchange of goods and ideas can happen quickly

and this intensity of activity provides some of the strongest economic motivations for retaining vibrant, dense cities, as described elsewhere. Yet, the transport cost reductions from agglomerating activity in cities can slow or even be reversed as cities become congested or as their spatial organization stifles the efficient movement of goods, people, and ideas.

To better understand the current influence of spatial organization and transportation costs on economic activity, we must briefly consider the economic theory underlying the spatial structure of cities. Where businesses or residences locate within space depends on their willingness to pay (WTP) for particular locations. WTP is influenced by the utility that businesses or residences can derive from that location, which can come from both economic and non-economic factors. For businesses, profit drives WTP; businesses will locate where they can generate the maximum profit from their enterprise. Businesses must consider their location in relation to the location of their suppliers, markets, and employees, as well as where the business can obtain the most favorable government service and tax package. Residents must typically consider their housing location in relation to their employment as well as other supporting services, such as schools, transportation, and amenities, which are in turn derived from residential public service and tax packages. Theoretically, businesses or residents compete for desirable land and the competition for land ensures that "land is allocated to its 'highest and best use'," i.e., that land is allocated efficiently in an economic sense (O'Sullivan 2002, 175).

One of the major influences on the desirability of land comes from its *accessibility*; or how easy the location is to reach from other locations via available transportation modes (sometimes called *destination accessibility*). Locations near to export nodes, such as ports or airports, often command high property values because their accessibility minimizes costs to transport goods (Fujita and Mori 1996). Locations well-served by personal transportation

networks, such as a central train station connected in a hub-and-spoke system to supporting rail lines, also command high property values because their accessible locations minimize transport costs for interacting with clients and suppliers. Often, the combination of central export nodes and high demand by manufacturing and office firms for accessible nearby locations results in core-oriented cities surrounding by residential development. Indeed, such monocentric cities serve as the starting point for much urban and regional economic theory (e.g., Alonso 1960).

Contemporary urban areas tend to be more dispersed across space as transportation costs, especially for moving goods and people, have declined dramatically over the past century (Glaeser 1998; Anas and Moses 1978). Transportation costs declined in part because of technology improvements (including communications technology improvements, which reduce the need for some physical interactions) and the restructuring of the global economy away from manufacturing activities. Cost reductions are also a result of extensive public investment in roads in the U.S., which have made even remote locations relatively accessible by automobile or truck today (Mieszkowski and Mills 1993). Our ubiquitous road network means that manufacturing firms can locate in non-central locations closer to their inputs or where service and tax packages are cheaper. Office firms can select non-central locations that may be closer to their suburban workforce or consumer base. Higher-income workers, in turn, can locate further from central nodes or from public transportation routes due to relatively high auto accessibility even in many remote locations.

Location decisions, in turn, structure daily travel behavior. Daily travel imposes both time costs for the traveler and additional costs that typically vary with distance traveled, such as for personal auto operation (gasoline, parking, insurance, etc.) or for transit fares. Daily travel also imposes some cost on the regional transportation network.

Longer travel distances that result from individual location decisions are not necessarily a symptom of regional economic inefficiency. For instance, individuals may choose to live in suburban or rural areas despite the knowledge that doing so may increase their personal travel costs. To the extent that these costs are internalized into the location decision calculus and do not pose significant external costs for other residents or businesses, this arrangement may be economically optimal. In addition, some relocation of activity away from heavily congested areas may bring external benefits to the entire region.

Economic inefficiency arises when myriad individual decisions of residents and/or businesses to "move out" may pull apart the spatial fabric of the region to the point where the entire region becomes inefficient to serve by conventional infrastructure and costs rise for everyone. In this situation, the traditional benefits of cities – to decrease the costs of moving people, goods, and ideas – no longer accrue. (Note that similar inefficiency also may exist in regions that have not yet achieved the degree of urban concentration required to provide transportation cost reductions.) Public transportation, in particular, requires concentration of activity around nodes and along feeder lines to function efficiently. Public transportation also requires consistent patronage to support its annual operating and maintenance costs. Regions without effective public transportation place their travel burden almost entirely on road networks, which are prone in growing areas to become congested and which increases all travelers' travel times and fuel requirements. Building more roads in congested locations does not usually help, due to a well-documented phenomenon known as "induced demand" (Downs 1992; Gillham 2002). Regions without effective public transportation are also particularly susceptible to energy price shocks, such as the run-up in gasoline prices most recently experienced in the summer of 2008. The never-ending challenge for regions is then to foster an

organizational structure that maximizes the transportation cost-savings derived from urban concentration while minimizing impacts from congestion on businesses and residents.

2. Evidence

The literature regarding the impact of spatial organization on transportation costs is far from settled (Guo and Chen 2007; Cervero and Duncan 2006). The best available data on travel behavior in the U.S. concerns the journey-to-work, and as a result, most literature focuses specifically on commuting costs (reviewed separately below). Yet, approximately 80% of personal trips in the U.S. are conducted for purposes other than commuting (according to the 2009 National Household Travel Survey), and a growing amount of travel is oriented around freight movement. Thus, the spatial efficiency of a region is likely to have impacts on travel costs generally, which in turn are expected to impact a region's economic development as described above.

a) Spatial Efficiency and Driving

Newman and Kenworthy (1989) sparked a debate in the planning community with their conclusion that land use and transportation planning differences among 32 cities worldwide appeared to account for some of the variation in gasoline use per person, after considering differences from energy prices, income, and vehicle efficiency. Their most frequently cited finding was a nonlinear and declining relationship between density and energy use: the lowest-density cities (all in the U.S.) had the highest per capita gasoline use and highest-density cities had the lowest per capita gasoline use. The authors then advocated for creating denser, more compact and centralized city-regions as a policy strategy to reduce auto-dependence and encourage non-auto travel.

The Newman and Kenworthy studies have been frequently criticized in the research literature, especially regarding methodology and comparability of cases across countries, although studies in the U.S. context often conclude with similar policy prescriptions. For instance, residential density was the strongest predictor of both vehicle ownership and use across neighborhoods in Chicago, Los Angeles, and San Francisco, after controlling for household income and size (Holtzclaw et al. 2002). The authors were able to produce similarly shaped non-linear relationships between residential density and vehicle use as were produced by Newman and Kenworthy for density and gasoline use per capita. Transit availability was also found to be important to the auto ownership choice, while pedestrian/cycling friendliness was important in understanding auto use (Holtzclaw et al. 2002).

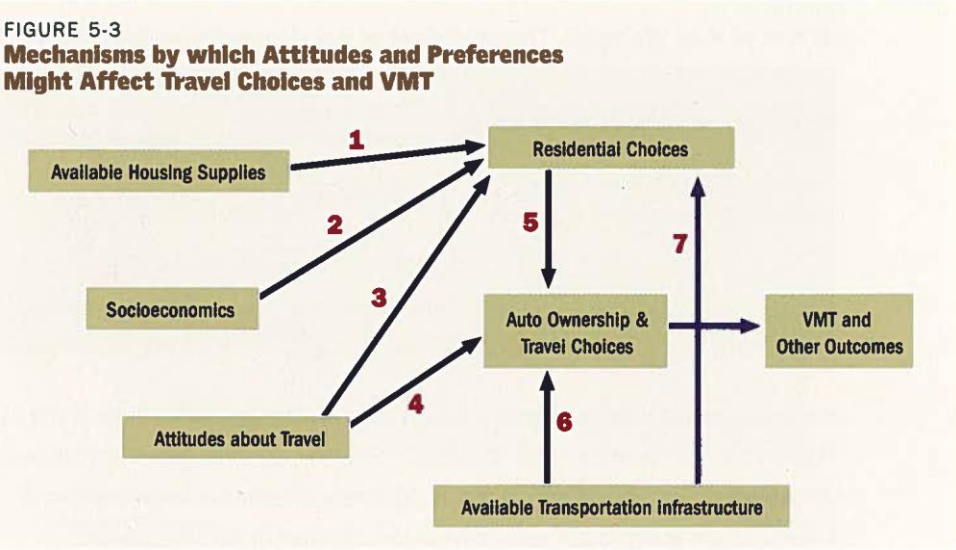
Holtzclaw and other researchers argue that individual suburban neighborhoods should be designed to discourage auto-use and encourage non-auto travel models. Such "neotraditional" or "new urbanism" design features might include higher densities, finer-grain land use mixing, shorter street blocks within a gridded street pattern, all of which presumably brings destinations into closer proximity and shortens trip lengths, thereby potentially making non-auto travel modes more attractive. Areas that have historically adopted such design features, such as urban neighborhoods in the Netherlands, do often have lower car use when compared to their more suburban and rural counterparts (Dieleman, Dijst, and Burghouwt 2002).

The problem is that neighborhood design features do not unambiguously result in less auto-use; by reducing trip lengths and the associated cost of travel between locations, such design features may theoretically increase the number of auto trips and thereby increase net auto travel (Crane 1996). Certain household characteristics, such as two-worker households with kids, are closely associated with auto use regardless of income or other urban structure factors

(Dieleman, Dijst, and Burghouwt 2002). Recent research in the San Francisco Bay Area found that households in jobs-rich (i.e., accessible) areas made more frequent vehicle trips but their net vehicle miles (and vehicle hours) traveled were lower than households in jobs-poor areas (Cervero and Duncan 2006). Whether reducing trip distances leads to reduced overall travel appears to depend on whether the area also experiences reduced speeds (such as from traffic congestion or specific traffic calming design features) enough to discourage short vehicle trips (Boarnet and Crane 2001). It also appears to depend on whether trip lengths are reduced sufficiently to entice non-auto travel, as many people appear unwilling to walk to destinations outside of ¼ mile (Boarnet and Crane 2001).

Self-selection bias is an important problem to consider when inferring the potential policy impact of changing spatial structure on transportation costs. That is, households may choose their location based on their preferences for transportation costs, and thus without adequate analytical controls for preference (or socio-demographics, which some say can simulate preference), studies may overestimate the potential response in driving behavior to land use change. Ewing et al. (2008) explain the primary relationships as follows:

FIGURE 2. MECHANISMS AFFECTING PERSONAL TRAVEL OUTCOMES (SOURCE: EWING ET AL., 2008, P.95)



A recent study investigating self-selection bias in a sample of households in San Francisco found that the built environment (i.e., buildings and infrastructure) influenced both whether the household owned a car and where the household located within the metropolitan region (Bhat and Guo 2007). Yet, the research found that household socioeconomics, especially income, dominated the decision of where to live within the region, and thus the researchers cautioned against oversubscribing impacts to the built environment (Bhat and Guo 2007). Research in Germany found a larger influence of the built environment on household location and driving behavior after controlling for household socioeconomics and potential self-selection bias (Vance and Hedel 2007). Unfortunately, German cities tend to have much more substantial transit offerings than U.S. cities (as well as have other policy, governance, socioeconomic differences discouraging auto travel), limiting its comparability to the U.S. context (Transportation Research Board 2009; Rodier 2009).

The most recent and careful empirical study on the influence of neighborhood-level urban form on travel behavior found nuanced relationships between neighborhood density, vehicle

usage, and fuel consumption when controlling for socio-demographics (Brownstone and Golob 2009). The authors conducted a structural equations analysis to predict fuel consumption based on vehicle usage (VMT) and density, based on a sample of household travel behavior from California in 2001. The authors found that the net effect of increasing residential density by 1,000 housing units per square mile (40% of the mean) was to decrease VMT by 1,171 miles per year per household (5%) and reduce fuel consumption by 64.7 gallons per year per household (5.5%), all else equal. The density effect was a compound result of driving fewer miles in dense areas, owning fewer vehicles in dense areas, and owning more fuel-efficient vehicles in dense areas (likely as a response to parking constraints).

There remains substantial debate as far as the magnitude of impact that could be generated by altering land use and regional spatial structure. One widely-cited study argued that moving a hypothetical household from a region with a sprawling spatial structure like Atlanta to a region with a more concentrated spatial structure like Boston could decrease household VMT by nearly 25%, with even larger gains to be had by moving to a region with highly concentrated spatial structures like New York and Chicago (Bento et al. 2005). Ewing, Pendall and Chen (2003) found a difference of approximately 25% between driving behavior in the most sprawling regions and in the least sprawling regions within their sample of U.S. metropolitan areas. Likewise, Ewing et al. (2008) found that doubling gross population density across an urbanized area could decrease regional driving by approximately 15-20%.

A recent scenario analysis found the potential for behavior change to be smaller (Transportation Research Board 2009). For the scenario with a doubling of density of 25% of new housing (which decreases VMT in these households by 12%), the authors found an approximately 1% nationwide reduction in VMT by 2030. For the scenario with a doubling of

density for 75% of new housing (which decreases VMT in these households by 25%), the authors found an approximately 8% nationwide reduction in driving by 2030. Part of the change in driving behavior was expected due to use of smaller, more efficient vehicles in denser areas and to some shift in travel from personal vehicles to public transportation (Transportation Research Board 2009). The authors discussed the feasibility of changing development patterns as modeled in their analysis, noting that even the doubling of density in 25% of new housing units would be a significant departure from recent trends, which have been towards lower densities.

Other scholars have expressed skepticism over the ability of policy or planning to influence spatial structure to the degree necessary to meaningfully impact driving behavior (Brownstone and Golob 2009; Brownstone 2008). For instance, one careful analysis concluded "that we still understand too little about [the transportation-land use] link to design informed policy" and "that we have other options available that can better meet the transportation planning needs of the immediate future" (Boarnet and Crane 2001, 14).

Despite skepticism in the social science research community, the planning and engineering communities have virtually accepted that land use is an effective strategy to reducing driving behavior and its associated energy and environmental impacts (Rodier 2009; Ewing et al. 2008). Increasing destination accessibility or proximity to transit will automatically reduce driving demand in commonly-used simulation models (i.e., TRANUS; MEPLAN; UrbanSim). Depending on the area studied, input parameters, and stringency of the modeled land use change, such simulation models have predicted between 0-10% reduction in regional vehicle miles traveled over 40 years, with a median reduction of 1.7% (Rodier 2009). Rodier (2009, 20) suggests that land-use only policies may have only marginal impacts in areas with

high quality transit (i.e., at least 10% commuting via transit, such as in European and Washington, D.C. regions), but may have stronger impacts in "the more sprawling and rapidly growing regions (e.g., Sacramento) where trend land use patterns do not take full advantage [of] existing transit capacity."

Adding investments to transit systems or auto pricing policies (such as the congestion pricing adopted in downtown London) to land use policies may have a much larger combined effect on costs over a 10-40 year period than land use policies used alone (Rodier 2009). For instance, adding transit improvements to land use scenarios may bump up the VMT reductions to 25% over 40 years (median 15.8%), whereas adding auto pricing policies to transit policies may bump up VMT reductions to 40% over 40 years (median 17.1%). The largest potential reductions appear from a combination of all three types of policies (land use, transit improvements, and auto pricing) at up to 80% VMT reduction over 40 years (median 24.1%). As Rodier (2009, 19) notes, however, "these policies may be considered very aggressive in the U.S. context" and may be difficult to implement. It is also worth noting that a few simulations found that aggressive pricing and land use policies result in increased regional VMT over time as businesses and households relocate away from high-cost central locations (Rodier 2009).

In addition, few researchers consider potential costs once a region hits a certain density level and roadways become congested, which can bring widespread costs to an entire region. For instance, Sarzynski et al. (2006) found that two measures of roadway congestion – the average number of vehicles on the freeway and the average hours of congestion delay per capita – were both higher in regions with higher regional density, after controlling for previous levels of congestion and for other land use variables, such as proximity of jobs and housing and degree of centralization. Regions with highly centralized housing also tended to suffer more roadway

delay per capita. These findings suggest that increasing regional density or housing concentration in an already congested region may be unlikely to reduce the costs of roadway congestion. That being said, a certain level of regional congestion is required to make transit systems more desirable and efficient to operate, and thus the end goal for regions may not always be to reduce highway congestion. One study noted that "congestion can be an ally of planners who seek to eliminate automobile trips, as some reduction in trip speeds, possibly due to increases in congestion created by higher densities, can provide an incentive for persons to avoid driving" (Boarnet and Crane 2001, 173). Readers are left with the somewhat incongruous conclusion that travel costs may need to increase (via congestion) to decrease travel costs (from reduced driving).

Finally, while most research attention has been focused on residential density, some researchers note that increasing employment density, especially in centers and around transit stops, may improve accessibility for workers and businesses throughout the region and be more likely to reduce regional transportation costs than increasing neighborhood residential density (Transportation Research Board 2009; Ewing and Cervero 2001). Unfortunately, few empirical analyses compare such potential scenarios and most simulation studies combine both increased residential density and employment concentration in the same scenario, making it difficult to compare the effectiveness of different densification policy strategies.

b) Spatial Efficiency and Commuting Costs

Although commutes comprise only a fraction of total transportation behavior (i.e., less than 20 percent of daily trips), their importance in structuring daily activity makes the journey-to-work a robust area of research activity. The abundance of research has not revealed consistent findings, however. Some of the variation in results come down to analysis of different aspects of

commuting behavior, such as commute times vs. commute distances or travel mode, or from differences in how those measures were computed (i.e., estimated distance or measured with an odometer). Longer commute times may illustrate spatial inefficiency with respect to economic prosperity because time spent commuting is time that cannot be spent in other productive activity. Additionally, commuting travel distance and travel mode both have important implications for transportation planning, traffic congestion, energy use, and environmental pollution. Other variation in results comes from whether the analysis considers aggregate behavior (such as averaged for residents in a particular region) or considers individual commuting behavior. Further variation is introduced because researchers use different measures of spatial efficiency, such as density or degree of centralization, and specific measures may not be comparable across studies or over time.

Research using aggregate measures for a regional geography has often found that average commuting times are longer in regions with higher average density (Levinson and Kumar 1997; Izraeli and McCarthy 1985; Gordon, Kumar, and Richardson 1989). Yet, regional density (measured at the metropolitan or urbanized area level) may act more as a surrogate for city size or urban age than as a measure of intra-regional spatial structure. In addition, when examined in light of other measures of spatial structure, the relationship between regional density and commute times is not obvious (Sarzynski et al. 2006; Ewing, Pendall, and Chen 2003). Using regional measures of spatial structure may also obscure important differences in commute behavior and costs found within the region, as spatial structure is rarely uniform across an entire region.

For this reason, scholars have further investigated the relationship between commuting behavior and residential densities measured for smaller geographies, such as census tracts or

blocks. Some of this research has found relatively consistent travel times across different locations for both commuting and non-work behavior, whether in central cities or far-flung suburbs (Gordon and Richardson 1997; Levinson and Kumar 1994). One explanation for the relative stability of travel times arises when considering travel mode (Wang 2000). Commuters traveling by private automobile may travel further distances but travel faster speeds than commuters traveling by public transportation, who may travel less distance but at slower speeds. Travel distance and travel speeds combine to produce relatively stable average travel times. Another explanation is that commuters adjust their household or employment locations such that journey-to-work times remain relatively stable (Gordon, Richardson, and Jun 1991; Gordon, Kumar, and Richardson 1989). Businesses may also adjust their location to be closer to their workforce. The dynamic adjustment of businesses and residents to minimize commute times is discussed in the literature as the "co-location hypothesis" (Cervero and Wu 1998).

Although varying considerably in methodology, study area, and specific findings, econometric research has often found that the attributes of neighborhoods are correlated with the commuting costs of its residents. For instance, using a national dataset of individual commute trips in 1990, Levinson and Kumar (1997) found that the relationship of commuting time to neighborhood density was non-linear for commutes by automobiles; commute times declined as density dropped below 7,500 persons per square mile but increased with density above 10,000 persons per square mile. The increase in commute times via automobile from high density neighborhoods appeared to represent a congestion disamenity effect, as predicted by economic theory. Transit commuters, by contrast, did not experience a disamenity effect from higher density living, which may reflect the fact that transit works better in high density neighborhoods (Levinson and Kumar 1997).

Another study using a national dataset of households in large U.S. cities found that both neighborhood density and the nearby mix and proximity of land uses had important impacts on the choice of commuting mode (i.e., driving vs. transit, walking, or biking) in 1990 (Cervero 1996). Workers tended to chose non-auto commuting only when their neighborhood density was high and when there was a mix of non-residential land uses within close proximity (i.e., 300 feet) of their homes (Cervero 1996). Similar results were found from household travel surveys from Seattle and Toronto (Frank and Pivo 1995; Miller and Ibrahim 1998). These studies suggest that we cannot focus exclusively on density, but rather must look at how density is patterned throughout the region.

More recent analysis has affirmed that commuters living in low-density outlying suburbs of relatively monocentric regions tend to commute further and longer than commuters living in higher-density close-in neighborhoods (Sultana and Weber 2007; Miller and Ibrahim 1998; Wang 2000; Shen 2000). Yet, travel requirements between suburban homes and suburban jobs may be less than travel requirements between suburban homes and city jobs (or city homes and suburban jobs) (Sultana and Weber 2007; Gordon, Kumar, and Richardson 1989; Schwanen, Dieleman, and Dijst 2003). These findings suggest that commuting costs depend critically on both residential and employment choices and opportunities. For instance, Levinson (1998) found that increasing the availability of jobs in housing-rich suburban areas (as well as increasing the availability of housing in jobs-rich areas) decreased individuals' automobile commute times in the core-dominant Washington, DC region. Similar results were found regarding employment accessibility in Boston and Chicago, which both have large central cities (Shen 2000; Wang 2000). Sarzynski et al. (2006) confirmed that metropolitan areas with relatively close proximity

of jobs to housing (i.e., Las Vegas) had shorter average commute times in 2000 than areas with housing further from jobs (i.e., New Haven).

Even so, research has not consistently demonstrated region-wide benefits from employment decentralization on commuting. For instance, the San Francisco Bay area did not experience shorter average commute distances or times following rapid employment decentralization from 1980-1990, nor were commute times shorter in decentralized city-regions in the Netherlands as opposed to more centralized regions (Cervero and Wu 1998; Schwanen, Dieleman, and Dijst 2003). Commuting behavior clearly varies with city size and cultural factors, with results from medium-sized Quebec and from smaller regions in Europe diverging considerably from results found in Washington, Boston, or Chicago (Vandersmissen, Villeneuve, and Theriault 2003; Schwanen 2002). Part of the discrepancy may come down to the degree of congestion found within the study area, as decentralization in an already congested area may do little to improve commutes for local residents. Differences may also arise from transit availability, as the availability of alternatives to driving will most certainly influence the propensity of households to choose non-auto modes (Rodier 2009).

The empirical literature is also mixed regarding the relative importance of spatial structure on commuting costs. Most researchers acknowledge at least three types of factors that influence individual commute behavior: personal attributes (gender, age, education), household attributes (income, automobile ownership, married, young children), and spatial structure (Schwanen, Dieleman, and Dijst 2003). In several studies, personal or household attributes were found to be at least as important if not more important than location or structure in determining individual travel behavior (Sultana and Weber 2007; Bento et al. 2005; Punpuing 1993; Schwanen, Dieleman, and Dijst 2003; Giuliano and Small 1993; Cervero and Wu 1998; Guo and

Chen 2007). It is widely agreed that individuals self-select into the neighborhoods where they live for a variety of reasons and commutes may represent only one part of that decision calculus.

Other studies focusing on job accessibility near to residences have found accessibility to be the most important factor influencing individual commute times (Shen 2000; Levinson 1998). Shen (2000) also found a stronger influence of residential location on commute times for workers commuting by modes other than the personal automobile (i.e., transit, walking). Most studies using individual-level observations found a large degree of unexplained variation, suggesting that observable commute behavior may be only moderately influenced by socioeconomics or spatial structure (at least as measured by the existing literature).

A notable gap in the literature remains in tracing how changes in spatial structure over time impact commuting costs (Vandersmissen, Villeneuve, and Theriault 2003). Indeed, almost all of the existing literature draws conclusions about the potential impact of changes in urban structure using results of cross-sectional analysis or single case studies from which it may be difficult to draw causal inferences. Yet, what policymakers and practitioners need to know is whether interventions to change the spatial structure have noticeable effects on commuting. Such analysis is particularly difficult because regional spatial structure changes slowly, on the order of decades, and few datasets are available to model long-term impacts. In addition, much of the empirical literature relies on simple models of the relationships between land use and commuting behavior, despite methodological concerns about the simultaneous operation of land use and transportation systems and the presence of time-lags in observing behavior change (Sarzynski et al. 2006). For instance, analysis indicating only a minor influence of spatial structure on commuting behavior may result because complex relationships and interactions are difficult to model properly. In these cases, the best solution may be to employ regional

simulation models that consider the complex dynamic interactions between land and housing markets with transportation networks, which all impact the location choices of businesses and residents.

Thought exercises have been employed to illustrate the role of location choice on transportation costs. For instance, Persky and Wiewel (2000) compared the costs of congestion externalities for a hypothetical new electrical equipment plant locating in the outer suburbs of Chicago to those associated with a central city location. Using data from the 1990 Census, the authors found that 95% of suburban jobholders drove to work compared to only 61% of city jobholders, and rates of carpooling were higher among city jobholders. Using data on actual commute times and commuting modes, the authors estimated that the average suburban worker generated about 30% more vehicle time than did the average city worker. Simulating the projected congestion increases resulting from a city versus a suburban location, the authors estimated that a city location resulted in approximately 47,000 fewer commuting hours than did an outer suburban location. Assuming that congestion costs $0.35 per mile and the average speed of travel in the Chicago metro was 30 miles per hour in 1990, these extra commuting hours carried economic costs of about $500,000 for the suburban location over and above the city location. In addition to the commuting costs, suburban households put 0.5 more cars on the road than central city households do; resulting in 250 more vehicles on the road as a result of the new firm choosing a suburban location, which resulted in an additional $100,000 in annual accident costs and an almost additional $20,000 per year in pollution costs. Together, the extra transportation costs required as the result of a single new suburban firm location equaled about $620,000 compared to the transportation costs required had the firm located in the central city.

Other thought exercises place the regional commuting cost savings from compact development at billions of dollars per year. For instance, commuters in Portland, OR and Chicago saved approximately $1.1 billion and $2.3 billion, respectively, in vehicle costs from shorter distance commutes compared to the median driver nationally (Cortright 2008, 2007). In Portland, shorter commutes were estimated to also save another $1.5 billion in commuting time, for a total annual savings of $2.6 billion (Cortright 2007). (Additional savings would be expected if residents drove less for other purposes besides commuting, such as for shopping or recreation.) Another scenario analysis placed the nationwide transportation cost savings at approximately $2.2 trillion over 10 years if all new development was targeted in smart-growth communities (50% greenfield vs. 50% infill), with even larger savings of $2.8 trillion if all new development was in smart-growth infill communities (Bürer, Goldstein, and Holtzclaw 2004).

Additional implications of reduced commuting costs on the regional economy should be considered. For instance, if residents are driving less to their jobs, are they using public transit more, and if so, how much does transit cost the region? And, if residents use public transit more, are they spending more time commuting as a result of slower travel speeds? If residents truly incur lower net commuting costs (from driving or alternatives) as a result of compact development, are wages lower as would be predicted by economic theory? If wages are lower, are residents made better off? Few analyses have been published that could help to answer these questions.

Given the degree of debate over underlying relationships and magnitudes of impact, the reader might rightly conclude that spatial efficiency is likely to be an important factor in structuring commuting behavior but that behavior is highly dependent on individual preferences

and other contextual factors about the region in which they reside, such as city size, age, climate, geography, culture, and governance structures.

C. Spatial Mismatch

The previous sections reviewed the transportation costs literature in a relatively general way. Here, we review the theory and evidence for the specific problem of "spatial mismatch," which is a key topic in the urban research literature.

1. Theory

A subset of the transportation efficiency problem just described arises when the geographic arrangement of housing and businesses makes it difficult for individuals to travel to the jobs that they are qualified to hold. Generally there are two assumptions behind arguments about this "spatial mismatch." First, there are spatial variations in resources offered by markets and/or institutions in and/or across metros; and second, households have unequal ability to reside in locations where markets and institutions are most desirable. Suburban zoning practices limit the ability of low-income individuals to reside in the suburbs, and racial discrimination can make suburban living particularly hard for minority populations (Holzer 1991). Formally, the spatial mismatch hypothesis "states that the suburbanization of jobs and involuntary housing market segregation have acted together to create a surplus of workers relative to the number of available jobs in central-city neighborhoods" (Ihlanfeldt 1999, 216). This mismatch results in an inability of city residents to find work, lower city wage rates, and higher commuting costs. When suburban job locations are inaccessible via fast and affordable public transit, commuting costs prove to be prohibitive for some individuals.

Spatial mismatch may produce concentrations of urban poverty, as many of the affected individuals live in inner city areas where human capital levels, incomes, and car ownership rates

are lower. This spatial mismatch is best characterized as economic isolation of inner cities; and in these cases, even cities in fast-growing regions are unable to achieve income gains and reductions in poverty (Blair and Carroll 2007). Concentrations of poverty in the city produce their own deleterious results in the form of neighborhood effects where peer influences increase the likelihood of antisocial and/or destructive behavior among individuals living in poorer areas. Neighborhood effects also occur when concentrations of poverty lead to a shortage of indigenous adults serving as role models and/or "enforcers" and when the neighborhood experiences an erosion of support for mainstream institutions such as schools and churches. Finally, neighborhood effects tend to reduce the informal sources of job information and career networks that might help people find employment (Ihlanfeldt 1999). Many of the consequential social costs, such as crime and urban blight, serve as a disincentive to firm location, thus perpetuating a cycle of urban decline.

Further, spatial mismatch results in otherwise employable individuals remaining unemployed. Evidence also suggests that individuals may be afraid to work due to concerns about being the victim of crime while traveling to work, having one's earnings stolen, and for what will happen to one's children during the work day (Ihlanfeldt 1999). On the personal level, spatial mismatch causes human capital to erode and disenfranchisement from the labor market. On a social level, it introduces inefficiency into the labor market in the form of underutilized human capital. Research shows that regions are most efficient and economically successful when they are able to use all of their assets, leaving no places or people behind (Pastor 2000; Weissbourd 2004). Spatial mismatch may also drive up labor costs for employers, introducing inefficiencies in the regional labor market. For instance, businesses in areas suffering from spatial mismatch may find it is harder to locate and attract skilled workers or may face higher

labor costs because of greater worker turnover and higher associated hiring and training costs, all resulting in higher labor costs and slower economic growth.

Spatial mismatches also result in increased government expenditures that take the form of: higher social service costs (such as welfare) to individuals who would otherwise be employed, higher police costs to deal with crime, and higher fire costs to deal with eroding housing. Higher costs are a particular challenge for cities since they frequently face higher public needs and a declining revenue base, simultaneously. In addition to fiscal constraints, many of the most capable providers of public services (such as teachers) will prefer to locate in better-off places. These fiscal and human resource constraints combine with transportation challenges and neighborhood effects to make the consequences of spatial mismatch mutually reinforcing (Ihlanfeldt 1999).

Spatial mismatch is a function of both the location of jobs and of the specific types of jobs available across the metropolitan area. In particular, trends suggest that jobs and the people qualified for them are moving in opposite directions with entry level jobs such as manufacturing, retail, and data-entry positions moving towards the suburbs while less-educated workers are increasingly concentrated in the inner city. At the same time, highly skilled professional jobs such as lawyers and management consultants are moving into the city, while the highly educated workers locate on the increasingly distant urban fringe (Dreier, Mollenkopf, and Swanstrom 2001). Such an arrangement of jobs and people not only increases transportation costs in a general sense. For the urban poor (who often do not own cars), the spatial arrangement may make it impossible for them to travel to the jobs they are qualified for – or transportation costs may be so high that they make the returns to work negligible given such workers generally only

qualify for low-wage positions. This type of spatial arrangement of resources is likely to produce a spatial mismatch, along with the associated economic costs for the region as a whole.

Finally, it is worth noting that regional geography is becoming increasingly complex. The traditional approach of viewing mismatch as a city vs. suburb phenomenon may be losing some of its relevance, as suburbs diversify and the line between cities and suburbs continues to blur. The principle of spatial mismatch remains the same, however; regions suffer when its residents cannot easily access employment opportunities, no matter their location.

2. Evidence Regarding Spatial Mismatch

A subset of the research literature has focused on the implications of "spatial mismatch" on commuting behavior. Spatial mismatches occur when individuals are unable to get to the jobs that they are qualified to hold. Evidence unambiguously suggests disadvantages for city residents compared to suburban residents, with city residents facing lower median incomes, higher poverty rates, higher unemployment rates, and higher labor force nonparticipation rates (Ellen 1999; Ihlanfeldt 1999). Further, these disparities have been increasing over time, and the 1980s witnessed the development of a pronounced employment gap between central city and suburban blacks (Holzer 1991). However, while outcomes for city residents are inferior to those of suburban residents (particularly those of black residents), quantifying the extent of spatial mismatch has proved somewhat troublesome. The major challenge in this field of research is that residential location decisions are endogenous with employment availability, making it difficult to determine whether individuals less likely to work are choosing housing more distant from job opportunities (such as because they can't find affordable housing near to jobs) or whether the lack of job opportunities is responsible for the inferior labor market outcomes observed in central cities.

In an early review of the literature, Holzer (1991) describes four types of research approaches used to assess the impacts of spatial mismatch on employment outcomes. The first type of studies measures spatial mismatch in terms of residential segregation by relating the neighborhood-level racial employment concentrations to neighborhood-level racial residential concentrations. These studies are generally interested in assessing the extent to which residential racial segregation results in inferior labor market outcomes for minorities as opposed to assessing the extent to which the geographic arrangement of housing and employment results in inferior labor market outcomes for residents of specific neighborhoods. Further, results of these studies can best be described as inconclusive. A second type of study assessing the impact of spatial mismatch looks at residential suburbanization, using individual-level data to focus on wage or employment differentials for suburban and city residents while controlling for personal characteristics. While these types of studies have found evidence that city residents experience inferior labor market outcomes relative to suburban residents, studies of this nature are most likely to overstate such differences as a result of the endogeneity between residential location decision and employment outcomes.

Ihlanfeldt describes one mechanism for dealing with the endogenous residential location decisions and employment outcomes: focusing on the outcomes of youth still living at home since presumably their parents made the residential decision. For this group, existing literature does suggest the presence of a spatial mismatch, but only for larger metropolitan areas. Generally, the impact of the mismatch is directly proportional to the size of the region, with no impacts observed in areas of less than 1 to 1.5 million people. The extent of neighborhood effects are even harder to measure, but existing evidence has shown that teen pregnancy,

criminal activity, illegal drug use, alcohol use, church attendance, and idleness (neither attending school nor working) are all positively impacted by peer decisions (Ihlanfeldt 1999).

Another method for addressing the endogeneity of housing and employment decisions is to correct for it statistically using a treatment effects model adapted from the Heckman selection model. This approach creates a predicted probability of living in the suburbs based on individual characteristics and includes that predicted value in the econometric equation to control for the factors that would drive housing location decisions. Using this approach, Cooke (1996) finds that after controlling for these factors, residential location has an impact on employment outcomes in some metropolitan areas but not others. More specifically, in Dallas, Los Angeles, New York, and Washington DC, living in the suburbs increases respective employment probabilities by 11%, 12%, 26%, and 9%. On the other hand, in Cleveland, Houston, Memphis, and Newark, there is no relationship between living in the suburbs and the probability of employment. Cooke notes that the metropolitan areas with evidence of a spatial mismatch tend to be larger in terms of total population, African American population, retail and service sector employment, and total land area. However, he does not find that these metropolitan areas have disproportionate suburban shares of employment, retail and service employment, or total land area, though they do have smaller suburban shares of African American residents and longer average central city commuting times.

A third strategy for assessing the impact of spatial mismatch described in Holzer's literature review (1991) is to focus on job suburbanization. These studies also avoid the endogeneity issue, in this case by focusing on the decentralization of employment. Some studies using this approach have found that employment decentralization has led to inferior labor market outcomes for central city residents, while others have no observed an impact. In addition to the

ambiguous findings, Holzer notes that employment decentralization may be the result of city characteristics such as crime and vandalism, which are themselves functions of central city employment rates (and other personal characteristics), thus introducing another source of endogeneity.

A final approach for addressing the importance of spatial mismatch in labor market outcomes is to use more direct measures of job access, such as commuting times or job availability within Census tracts or other zones in a specific metropolitan area (e.g., Shen 2000). While these studies do generally observe reduced access to jobs among inner-city blacks, the differences are relatively small when compared to the time spent working per day, and though statistically significant, often lack substantive significance. Further, the results are very sensitive to the choice of metropolitan area confirming that some metros are sensitive to spatial mismatches while others are not (Holzer 1991).

In a review of the literature published after Holzer's literature review, Ihlanfeldt and Sjoquist (1998) found 28 additional studies published, 21 of which concluded their results supported the existence of a spatial mismatch. Further, they argue that the 7 studies that did not find a relationship failed to account for the endogeneity of residential location, suggesting that spatial mismatch is indeed a real phenomenon. Nonetheless, the authors note that its importance varies across metropolitan regions, with regions characterized by high housing segregation and poor transportation for reverse commuters most likely to have spatial mismatches resulting in labor market problems for the inner city poor. Further, spatial mismatch is only likely to occur in big cities. Finally, the authors note that the spatial mismatch phenomenon is a function of much more than the geographic arrangement of jobs and housing. In fact, the absence of information on suburban job opportunities, reluctance on the part of blacks to search for jobs in

white areas for fear of not being accepted, racial discrimination on the part of suburban employers, and a lack of public transit options for commuting from the inner city to suburban employment centers are the primary barriers to employment for inner city minorities.

One study attempts to draw from several of these different research approaches in assessing the results of spatial mismatch in 1990 (O'Regan and Quigley 1998). This study is concerned in particular with employment outcomes for black youths and the impacts of social isolation (measured in terms of exposure to poverty and different racial groups) and job access. In an example of the residential segregation research approach, the authors use metropolitan level data and find that there is a positive relationship between black youth unemployment rates and social isolation in terms of contact with poverty. In their residential suburbanization approach, they analyze unemployment rates for central-city black youth and suburban black youth, finding that both racial and poverty isolation are directly related to unemployment rates at the metro level and indirectly related to the probability of employment at the individual level. Finally, using the approach of direct measures of job access, they find both social isolation and job access measures are related to individual employment probabilities, but that these relationships differ across the four New Jersey metropolitan areas they chose to study (Newark, Bergen-Passaic, Middlesex, and Monmouth). The differences in their findings across regions are rather striking. For example, in Bergen-Passaic, only about 6.0% of the difference in black-white employment rates can be attributed to a spatial mismatch, while in Newark, about 39.4% of the employment gap is the result of spatial mismatch. The authors conclude that:

> The results confirm the fact that the largest source of disparities in employment rates between whites and minority youth is the discrepancy between the average human capital and household characteristics… [They] also suggest that a substantial fraction of

> the differences in employment outcomes by race is attributable to intra-metropolitan spatial factors. Of these, social access or exposure seems to be more important than job access as measured by proximity to employment. (O'Regan and Quigley 1998, 1201)

Taken as a whole, it appears that spatially inefficient regions are likely to suffer from spatial mismatches that result in involuntary employment among low-income, uneducated city (predominately minority) residents. While this phenomenon is most likely in larger urban areas, it is less clear what other circumstances are most likely to produce a spatial mismatch. Some likely culprits include housing segregation by race and income, inadequate public transportation for reverse commuters, and racial discrimination. Despite this evidence of a spatial mismatch in at least some metropolitan areas, existing literature has yet to empirically demonstrate a relationship between spatial mismatch and metropolitan economic growth.

D. Public Services

1. Theory

In addition to public costs that result from a spatial mismatch, the spatial arrangement of housing and business is a major determinant into the costs of public services such as roads and bridges, municipal waste management, fire and emergency services, and education. Many of these services require fixed infrastructure, such as roads, fire stations, and schools, and this infrastructure is costly to construct. As regions grow, they require additional public infrastructure including but not limited to roads, water and sewer infrastructure, and public buildings. When deconcentration reduces overall density, these facilities must be constructed in such a way that new facilities are serving fewer average numbers of residents, resulting in higher per capita municipal expenditures (Burchell 1997). In cities with a small or declining population, infrastructure maintenance requirements add additional inefficiencies into the

provision of public service. Higher public service costs require higher taxes, which are a deterrent to economic growth.

2. Evidence

There are many ways in which the spatial efficiency of a region may impact the price of public services. As noted above, spatial mismatches increase demand for public services. Similarly, geographic expansion will increase the demand for public services in lands previously uninhabited. However, it is also possible that in addition to increasing demand for public services, spatial efficiency may impact their cost or price. This section is specifically concerned with this latter price impact.

Literature describing a relationship between spatial efficiency and the per unit cost of public services begins with the premise that decreased density requires an expansion of infrastructure causing the marginal price of new service locations to exceed their average price. In particular, the extension of roadways and venues providing utilities requires these services to travel further to reach relatively fewer numbers of people. To the extent that other services such as police protection and education exhibit economies of scale, per unit costs of these services will rise as well. Their infrastructure requirements (such as schools and police stations) also exhibit increasing marginal costs with reduced density.

Unfortunately, there is little conclusive evidence as to the existence of this relationship. The most widely cited study of this phenomenon is the Real Estate and Research Corporation's 1974 report *The Costs of Sprawl*, which found that public services in sprawling regions cost about twice what they would in denser regions. More recent research has also found a negative relationship between density and the price of public services, both in the aggregate, and for specific services such as roadways and sewers. Research also generally finds that the cost of

public services rise with the spatial extent of urbanized land, making sprawl doubly inefficient from a public service provision prospective. More specifically, Carruthers and Ulfarsson (2003) find that density (defined as the number of jobs and residents per square acre of *urbanized* land) and the spatial extent of urbanized area (defined as the total number of developed acres) are both inversely related to per capita public sector costs in the areas of police protection, highways, and schools. Carruthers and Ulfarsson (2008) find that the density of developed land reduces local government spending and the spatial extent of developed land increases public expenditures. Based on these findings, the authors estimate that if the entire nation's land use had developed 25% more densely, 2002 fiscal year local public expenditures would have been $3.63 billion less, while if existing development had occurred in 25% less land area, they would have been $6.56 billion less. These savings translate into an average per county cost reductions of $1.18 million and $2.13 million, respectively.

However, there are also reasons to believe that the price of public services declines with low-density, sprawling regions. As Carruthers and Ulfarrsson (2003) note, newly urbanizing areas often are associated with the creation of new local governments and/or special districts in order to keep pace with increased demand for public services and increasing revenue needs. The creation of such institutions and sprawling land use outcomes are simultaneous as these types of governments are essential for the development of urban fringe suburbs, but they also often impose fiscal zoning and growth control strategies that lead to less dense development. The Teibout model of metropolitan governance suggests highly fragmented areas with multiple governmental authorities should have *lower* per capita municipal expenditures since the large numbers of governing bodies introduces competition into the system, forcing down costs. Indeed, Carruthers and Ulfarsson (2003) note that empirical research generally finds an inverse

relationship between the number of jurisdictions and their overall expenditures and in their own research, they find that the per capita number of special districts and the per capita number of municipal governments are both inversely related to per capita public expenditures, except in the case of roadways and trash collection.

Several studies have found that there is an inverse or U-shaped relationship between density and the price of public services. For example, Ladd (1992) looks at the relationship between population density and per capita local expenditures including expenditures from all local governments within each county including county governments, municipal governments, townships, education districts, and other special districts. Ladd's model of public expenditures specifies demand, cost, and public service preference variables; intergovernmental relations variables; and density and population change variables; and public expenditures are separated into current use, capital, and public safety. The hypothesized impact of density on public service costs is ambiguous. On the hand, there are potential economies of density in the production of public services. On the other hand, higher density requires that more services be provided through the public rather than private sector and increases the amount of public goods needed to provide a given level of public service. Ladd finds a U-shaped impact of population density on public expenditures; with the relationship being driven by the impact on current account and public safety spending. Where population is sparse, increasing density lowers public service costs, but after density reaches 250 people per square mile, public service costs increase. A county with population density of 1,250 persons per square mile is predicted to have public service costs 19% higher than a similar county with population density of 250 per square mile. About 13% of this increased costs come from public safety spending while the others come from current account increases.

As the above study indicates, critical to the findings reported in the literature on spatial form and public sector costs are the specific costs being assessed. For example, Carruthers and Ulfarsson (2003) report that higher density is associated with lower per capita police, road, and school spending but associated with higher spending in "other transportation" (which includes parking facilities and public transit) and sewerage. In a review of the literature, Slack (2002) notes that studies analyzing the costs of "hard" services (infrastructure such as local streets, sewerage collection lines, water distribution pipes, storm drainage systems, and local schools) find that denser areas have lower per capita costs. On the other hand, studies analyzing the relationship between "soft" services (education and social services, for example) find that small one- and two-bedroom, high-rent multifamily housing; and office, industrial, warehouse, and retail properties generate more in tax revenues than they require in expenditures (Slack 2002).

Also critical in understanding the relationship between density and public sector costs, is the size of the area. Holcombe and Williams (2008) argue that "the general conclusion is that for communities larger than 50,000, where most of the concern for sprawl is centered, higher population density does not reduce the per capita expenditures for providing government services" (Holcombe and Williams 2008, 360). In fact, for populations of over 500,000 increasing density is associated with higher per capita total and operational expenditures. However, the authors note that for infrastructure expenditures, there may be a negative relationship between spending and population density, although the negative relationships observed only hold for cities up to 250,000 in the case of highways and 500,000 in the case of sewers.

In addition to the size of the area and the type of expenditure being analyzed, the methodology matters. Studies of infrastructure costs (such as the widely cited Real Estate

Research Corporation's *The Costs of Sprawl*) are engineering studies analyzing the costs of infrastructure across hypothetical communities; and these tend to find an inverse relationship between density and public service price. On the other hand, studies such as the Ladd (1992) and Carruthers and Ulfarsson (2003) conduct statistical analyses using actual data on public expenditures. Generally, these latter types of studies are much more likely to find a positive relationship between density and public service costs, particularly where soft services are concerned (Slack 2002). Most of the studies above describe the relationship between per capita expenditures and land use.

An alternative approach to this question is the Cost of Community Service studies, which estimate the ratio of public expenditures to public revenues by land categories. These studies have the goal of estimating the impact of various land uses within a single jurisdiction and generally group land uses in residential, commercial/industrial, and agricultural/open space. In a meta-analysis of 125 Cost of Community Service studies, Kotchen and Schulte (2009) conclude that most studies find that commercial/industrial and agricultural/open space ratios are less than one (they generate more revenues than they require in expenditures) while residential uses are greater than one (they require more expenditures than they generate in revenues). Interestingly, as population density rises, commercial/industrial and agricultural/open space ratios about *doubles* while residential ratios remain unchanged. The authors admit that they have no explanation for the commercial/industrial result. On the other hand, they suggest that the reason for the higher expenditures relative to revenues in agricultural/open space land located in denser areas is that these tend to be smaller open space areas such as urban parks, which are expensive to maintain but bring in no revenue. With respect to the null finding on residential ratios, the

authors suggest that the density may be too crude to measure the actual impact of density on the costs of community service for residential property (Kotchen and Schulte 2009).

Similar to the costs of community service methodology, one approach to assessing the impact of spatial efficiency on public sector costs involves estimating the difference in net local fiscal contributions between alternative firm locations. Using this approach, Persky and Wiewel (2000) estimate that in 1990 Chicago, a new manufacturing plant located in the suburbs would cause about $1.5 million more public costs than the same plant located in the central city. The primary reason behind the larger public costs of the new suburban plant is the difference between average and marginal costs in public expenditures.

Together these studies do not provide particularly strong evidence for public sector savings associated with spatial efficiency, whether public sector costs are evaluated using a per capita expenditures or an expenditures relative to revenues approach. They do suggest potential savings on infrastructure resulting from a more compact urban form, but it is unclear to what extent these savings are offset by increases in operating costs. Given the somewhat ambiguous results presented here, if spatial efficiency improves economic growth in a region, it is unlikely that reduced public sector costs are the primary mechanism by which this outcome occurs.

III. Mechanisms & Intervention Strategies

The following sections review the factors influencing spatial efficiency and the primary strategies and interventions that might be pursued to improve spatial efficiency.

A. How Do Regional Systems Interact to Produce Spatial Efficiency?

Three factors have an immediate bearing on the spatial arrangement of economic activity within a region, including:

- Business location decisions

- Residential location decisions
- Provision of physical infrastructure

These factors are each the result of various systems interacting within the region, including labor and housing markets, the production process, and the transportation and political systems, as described in Chapter 2.

Business location decisions: Theoretically, businesses could locate anywhere, although we focus here on location decisions that happen once a business has chosen a particular region in which to locate. Typically, businesses locate where they can make the greatest profit, which is a function of the production process discussed in Chapter 2. Each business may have unique location requirements, which may relate to their type of business (i.e., manufacturing vs. professional services), size, profitability, and the locations of suppliers or customers. Business location decisions spatially anchor business interactions, meaning that location decisions determine the transportation, communication, and energy costs faced by businesses within the region and may influence their labor demand and profit margins. Businesses that are particularly sensitive to transportation or communication costs may locate in areas that are more spatially efficient.

Residential location decisions: Theoretically, households could also locate anywhere, although again we focus here on location decisions that occur once a household has decided to locate within a particular region. Households may choose locations based on myriad factors, as described in the housing market section of Chapter 2. Residential location decisions spatially anchor household travel, and thus determine the transportation, communication, and energy costs faced by households within the region. Of particular importance to regional economic development, household location decisions may influence labor supply and wages demanded by workers to compensate for their commuting costs, as well as contribute directly to their personal

welfare. Households that are particularly sensitive to travel costs may also locate in areas that are more spatially efficient.

Provision of physical infrastructure: Physical infrastructure knits together businesses and residences within the region, structuring their interactions and opportunities. Here, infrastructure includes transportation and communication networks, parks and recreation facilities, public education, health, and cultural facilities, and other public infrastructure such as water, sewer, fire, and trash facilities. Most of this infrastructure is supplied by public entities, such as county governments, although infrastructure may also be supplied by private entities for limited use, such as by homeowner associations. Thus, physical infrastructure is a tangible output of the region's political system, as described in Chapter 2. The provision of physical infrastructure both directly influences and is influenced by business and residential location decisions, both because businesses and residents create demand for infrastructure and because infrastructure is funded by taxes or fees charged to local residents and businesses.

These three factors interact to produce the continually changing land use and activity patterns observed within a region. All activities are constrained to some degree by regional climate, topography, culture, and history, as well as by previous location and investment decisions that may "lock-in" land use and activity patterns for years to come.

B. What Strategies Can Improve Spatial Efficiency?

Recall that spatial efficiency reflects the geographic arrangement of businesses, residences, and infrastructure that minimizes the effort associated with conducting essential economic activities. Economic activity is easier to conduct and can be more productive when the relevant parties are located in close proximity to one another. Thus, two primary strategies can improve spatial efficiency: foster co-location or improve connectivity.

First, spatial efficiency can be improved by encouraging businesses or residences to locate near to one another, known as co-location. Practitioners can employ various tools to influence location decisions, including designating growth areas and influencing neighborhood design. Influencing individual business location decisions may have the broadest impacts on the efficiency of the regional economy, especially for large employers, as many economic activities are oriented around each business location.

Second, regions may also invest in regional infrastructure to simultaneously reduce the time or effort required to conduct daily activities for many businesses and residents without changing their locations. Infrastructure investments to improve connectivity might focus on roadways, transit, communications networks, green space, or some combination thereof. Infrastructure investments may improve the desirability of particular locations and will influence future location decisions and economic activity for decades to come.

In many regions, spatial efficiency will be promoted by organizing economic activity around existing infrastructure, and especially at fixed points such as transit stations, highway interchanges, and existing activity centers, so as to make best use of current capacity and prior investments. Coordinating activity around existing infrastructure may reduce transportation costs for businesses, workers, or residents. Coordinating activity around existing infrastructure should also reduce public service costs for government, which may translate into lower costs for business and residents in these areas.

In some regions, however, activity-concentrating efforts may be counterproductive if the region suffers from severe congestion externalities that might be relieved by some degree of deconcentration. These regions may focus more on reorienting activity away from the most

severely-congested areas to less-congested activity centers, which themselves could be organized around existing or planned infrastructure.

Any strategy to influence spatial efficiency must take a long-term view. Both businesses and residents face high costs for relocating and location adjustments tend to occur slowly over time. Regions may be more able to influence new development than existing development. Similarly, large-scale infrastructure investments may be expensive and time-consuming to implement and require some certainty about future travel demand, which may be difficult to obtain in rapidly changing regions.

C. What Specific Interventions Can Improve Spatial Efficiency?

Practitioners have many entry points through which they might influence spatial efficiency. Many of the commonly-suggested interventions fall under the broad umbrella of "smart growth." A comprehensive review of each intervention is outside the scope of this analysis. Instead, we highlight four types of interventions that might improve spatial efficiency and foster regional economic prosperity, and which may benefit from thinking and acting regionally.

1. Designating growth areas to reduce travel and service costs

Various interventions limit the supply of available land for development, whether for open space conservation or more generally to delimit available growth areas, such as through zoning or growth boundaries. These interventions work by influencing the location decisions of businesses or households. Many interventions seek to limit development to areas surrounding existing infrastructure or to ensure that development proceeds with necessary infrastructure and to reduce public service costs (i.e., adequate public facility ordinances, impact fees). These

approaches have been adopted at the local level and by some states, including Oregon and Maryland.

Land supply restrictions tend to drive up the density and cost of development on available land, which should improve the spatial efficiency of a region and limit the effort required to conduct essential activities. Such increased density can only happen if zoning and other regulations allow for higher-density development and if the housing market (or office, retail markets) responds by supplying denser developments. Large-lot zoning and other exclusionary practices may intentionally limit densification and certain types of development. Densification and exclusionary practices both limit the availability of affordable housing within a jurisdiction and push the burden of providing affordable housing onto other jurisdictions within the region. The result may be to increase regional travel costs and potentially to create a spatial mismatch between the locations of available jobs and housing.

Thus, land supply restrictions may be most successful if coordinated at the regional level but combined with local rezoning or upzoning in designated areas that are connected to the regional infrastructure network. Local incentives may also be needed to ensure the supply of higher-density and affordable development in designated areas and to avoid the exclusionary consequences of land restrictions (i.e., special tax abatements, density bonuses).

Portland, Oregon provides one example of a coordinated regional planning regime directing where and how development can proceed. Passed in 1973, Senate Bill 100 requires each urbanized area to adopt a designated urban growth boundary. Local land use plans, zoning regulations, and business permitting processes are designed to expedite private development within the growth boundary. Outside the boundary, land is reserved for farms, forests, parks, or other natural areas. While the Portland metropolitan area still experiences some challenges, such

as a shortage of affordable housing, its growth boundaries have led to denser urban development, encouraged economic resurgence in poorer neighborhoods, preserved open space outside of the boundaries, and improved the regional quality of life (Rusk 1999).

Even without regional action, localities may designate special districts or zones for redevelopment. For instance, tax increment financing (TIF) is one tool for potentially improving both residential and commercial properties within blighted areas (Man 2001). Within TIF zones, property taxes levied on the original assessed value are sent to local taxing authorizes, while taxes levied on increases in the assessed value are used for infrastructure improvements and other economic development efforts. In general, properties in TIF zones have experienced larger increases in value than properties outside TIF zones (although the evidence appears context-dependent and most studies have not yet examined the regional impacts of such strategies). The combination of higher property values with improved public investment should draw jobs and services to needy areas and improve the efficiency of conducting business in and around the TIF zone.

Localities may also look to introduce or adjust impact fees to reduce the public sector's cost-burden for providing new infrastructure and services. Impact fees force developers to account for the true cost of the public services they receive and may encourage spatially-efficient location decisions when impact fees are lower in accessible locations. Carruthers and Ulfarsson (2003) argue that impact fees are not practical for the provision of ongoing services but represent a viable option for shifting the cost of new infrastructure construction to private sector beneficiaries.

2. Using neighborhood design to reduce travel costs

Many strategies aim to design or redesign residential neighborhoods so as to decrease personal travel costs and attract new residents. For instance, many planners advocate for neighborhood-level designs with short, gridded streets, sidewalks, higher density residential development, small neighborhood stores, good public transit access, and public open space. (For best practices, see Ewing (1996).) Residents of neighborhoods designed with these features tend to drive less and walk, bike, or use public transit more than residents of more car-oriented neighborhoods. These design features should improve regional efficiency by reducing personal transportation costs and improving labor supply, especially if these neighborhoods are strategically-oriented around a regional infrastructure network that connects residents with employment opportunities, markets, and other regional amenities. While much less studied, such strategies should also reduce transportation costs incurred by businesses for conducting daily activity. Extensive neighborhood redevelopment within a region may also moderate regional wages, as workers may demand less in wages to compensate them for their commuting costs, which in turn may impact business decisions about production.

Transit-oriented development and transit villages are frequently touted as the new design standard for accommodating growth in a spatially-efficient manner. Such development designs bring increased activity to transit service areas, which boost the potential riders on the network, and thereby may improve the viability and efficiency of the entire transit network. To succeed, transit-oriented development may require rezoning or upzoning (special districts or overlay zoning are common) and location incentives to ensure the desired type of development around transit stops.

Yet, many regions do not have high-quality transit networks and are predominantly auto-oriented. In these areas, as in high-growth areas, the focus may need to be on creating "transit-ready" areas, which are designed *as if* around transit stops but are not (yet) connected to the transit network. Residents and businesses may gain some of the travel savings from higher-density and mixed-use development, even if they cannot immediately benefit from transit availability.

Suburban neighborhoods may be more difficult to redesign to match the standards proposed for new development. Even so, many older suburban neighborhoods are well-connected to the existing infrastructure network. Redeveloping them makes best use of previous investments and may save considerably on future public service costs. Brownfields redevelopment, urban renewal-style initiatives, and other place-based strategies may reduce regional travel demands and produce a more spatially-efficient urban form. Even redevelopment of small commercial-strips along major arterial roads into more walkable, mixed-use centers may improve the accessibility of nearby traditional suburban neighborhoods.

3. Investing in infrastructure to reduce travel costs

The previous approaches influence spatial efficiency predominantly by influencing the location decisions of businesses or residents, and thereby influencing their activity and interactions. Alternatively, regions can focus on improving the infrastructure connecting businesses, residents, markets, and amenities, which should reduce the time and effort required to conduct essential economic activities and should influence business decisions about production. Common interventions include investing in public transit infrastructure, improving infrastructure management or operation, or subsidizing ridership, all of which can be achieved on an incremental basis and within a relatively short time period (less than 10 years).

Public transit investments can improve the destination accessibility of locations near to transit. Consider the impact of opening a new transit station. That station can serve residents and businesses that are already located nearby and may improve the viability of transit trips for residents or workers in other locations that need to access the area surrounding the new station. The new station may potentially relieve congestion at nearby stations or on area roadways if persons switch to using transit rather than driving on their own. Thus, by adding one station, regions can potentially make their entire transportation network (roadways and transit) operate more efficiently and reduce costs for many of the region's travelers. The new station may also improve the desirability of locating in the area surrounding the station, and thus influence future location decisions. Workers may find that they can forego the expense of operating and maintaining a personal vehicle once transit service improves in their area, reducing their overall travel costs.

Larger impacts are typically expected from fixed-transit investments, such as light rail and subways, than from bus transit investments. However, fixed-transit takes a long time to plan and secure necessary investment, and is quite expensive to construct. Few regions have the resources to open or expand fixed-transit offerings right now. Some public transportation advocates suggest that bus-rapid transit and other system improvements, such as express bus service, dedicated bus lanes, priority lighting for buses at signals, and raised bus stops may prove a faster and more feasible approach for reducing travel costs in cash-strapped regions. Such investments may also be more flexible in adapting to future travel needs than fixed-transit systems.

Transportation demand-management (TDM) tools, such as congestion pricing, parking restrictions, car sharing, and employer-based incentives including telecommuting, may also be

used to encourage less driving in auto-oriented regions, reduce congestion, and improve the efficiency of the regional economy. There is a delicate balance to be struck with congestion, however, as congestion is a necessary condition for encouraging behavior that is supportive of transit. Thus, the primary goal for regions may not always be to minimize roadway congestion.

Finally, regions may also benefit by providing subsidies to particular individuals that face difficulties conducting their daily activities with existing transportation options. Travel subsidies most typically include free or reduced transit fares (such as for children, students, the disabled or elderly), when the primary barrier limiting travel is affordability. Subsidies may also include subsidized parking or car sharing arrangements when existing public transit offerings are not adequate to provide mobility to jobs. These individually-targeted subsidies should reduce personal travel costs, which should improve labor supply decisions and alleviate some of the negative employment consequences of spatial mismatch.

4. Improving efficiency with regional planning and financing

Finally, residents and businesses benefit when development and infrastructure are coordinated and seamlessly integrated across jurisdictional boundaries within a region and beyond. Such coordination and integration requires long-term regional planning efforts, especially around fixed transportation infrastructure and green infrastructure (i.e., open land and connections that promote essential ecosystem services including habitat conservation, water filtration, etc.). Freight transport is one area that will benefit from long-term regional planning but that has received much less attention than may be warranted by its rapid growth in recent years (Brown, Southworth, and Sarzynski 2008).

One approach to promoting coordination between jurisdictions is regional tax sharing. Tax sharing allows a region to equalize the resources of local governments, providing at-risk

communities with the resources to lower taxes and improve services, while making regional land-use planning a legitimate possibility. Tax sharing is often cited as a way to improve the prospects of central cities facing declining tax bases coupled with increased crime rates and service demands from impoverished city residents observed in regions with a spatial mismatch. In Minneapolis, all taxing jurisdictions within the seven-county metropolitan area are required to contribute 40% of the increase in assessed commercial and industrial property value to a common pool, with revenues redistributed among taxing jurisdictions on the basis of population and tax capacity (Rusk 1999). In 2000, jurisdictions shared about 28% of the commercial and industrial tax base in the Minneapolis region, or about 12% of the total tax base, resulting in a 20% reduction in local tax-base disparities. Orfield (2002) argues that tax-base sharing reduces intra-regional fiscal disparities by 2 percentage points for each percentage point of shared resources, while state aid programs only reduce disparities by 0.5 percentage points for each percentage point of state aid, making tax sharing a more cost-effective means of improving intra-regional equity.

IV. Recommendations for Future Research

Our research indicates that improving spatial efficiency is likely to have positive economic returns such as through transportation or public service cost savings. However, there is a dearth of evidence directly connecting existing spatial structures with economic outcomes for regions.

First, we need a high-quality, long-term, comparative data set with which to evaluate spatial efficiency in a large number of regions. There is a lot of debate within the urban studies literature about how best to measure spatial outcomes and some researchers fall back on existing measures of urban sprawl, including simple measures of regional density. Yet, it is not clear

whether these measures are the most appropriate ones for research on economic outcomes. Most sprawl research focuses mostly on personal travel outcomes rather than on the conduct of other business activity or on public service costs, which are also likely to influence economic outcomes. In addition, most existing research has focused only on large metropolitan areas in the U.S. and we have much less information about spatial efficiency in smaller regions. These smaller regions may benefit the most from developing new spatial metrics, as these regions may have less capacity to conduct their own data collection and analyses.

Two strands of complementary research should proceed once we have a high-quality, long-term, comparative data set on regional spatial patterns. One strand of research would explore in more detail the conditions under which spatial patterns developed, furthering our understanding of why certain areas may be spatially efficient while others may suffer from various degrees of spatial inefficiency. What have the successful regions done to achieve their success? Can their actions be replicated elsewhere, and how? This research should help identify the particular actions that practitioners might take to obtain desirable spatial patterns within regions.

A second strand of research would explore in more detail the consequences of spatial patterns for economic development. That is, can we demonstrate that changing spatial structures have had a meaningful impact on regional economic growth, and under which circumstances? If not, why not? Further research could work to develop typologies of spatial structure in the context of economic development, and to delve more deeply into the conditions required to achieve positive returns such as through careful comparative, case-study analysis.

We should also explore the individual pathways through which spatial efficiency impacts economic growth in more detail. For instance, we need better information about which regions

suffer from spatial mismatch and why, and how spatial mismatch influences regional economic outcomes. Specifically, does the concentration of poverty and unemployment resulting from a spatial mismatch result in a shift of public sector costs from the suburbs to the city, or does it increase the region's overall costs? Does spatial mismatch result in a disproportionate number of unemployed individuals living in a concentrated area or does it increase the total number of unemployed in the region?

Related, we need a better understanding of how spatial patterns (beyond just density) influence public service costs and how those costs influence regional economic development. Currently, research finds that less dense configurations lead to higher capital costs and lower operating costs. However most research in this area looks at single jurisdictions rather than regions, resulting in a skewed view of the regional consequences of jurisdiction decisions. Such research might better employ a cost-benefit framework with a moderate time horizon that can account for both upfront and annual expenditures and that spans multiple jurisdictions.

Regions also need reliable evidence regarding which of the strategies and interventions mentioned above are most likely to change spatial structure and to bring economic benefits to their region, as well as at what cost. It would be useful to compile an open, online learning space where practitioners, academics, and others could submit information regarding local and regional strategies and their impacts. The learning space organizers could develop a template of items that all submissions should discuss so as to provide some degree of comparability. The organizers could also commission a regular paper series extracting lessons learned across cases and encourage feedback from the policy and practitioner communities as to what additional information or analysis would be necessary to improve their decision-making.

The authors of this report also urge that future research measure regional outcomes when evaluating local policies. Many strategies to improve spatial efficiency are targeted at small neighborhoods or only segments of cities (e.g. TIFs, Brownfield Developments, and Enterprise Zones). While existing research has evaluated the impact of these policies on the participating communities, it generally does not look at the impact of these policies on the region as a whole. Are the positive outcomes observed in development districts only achieved at the expense of neighboring jurisdictions or do the improvements in spatial efficiency benefit the region as a whole? Because the major systems in an economy operate at the regional (and not neighborhood) level, it is critical that policies undertaken to improve neighborhoods not undermine regional outcomes.

Finally, the research community should work with regional leaders and practitioners to develop better tools that can be used to understand regional dynamics. That is, practitioners need easy-to-use metrics for assessing their spatial efficiency problems and for identifying what would be optimal policy interventions given their unique economy and characteristics of place. The tools might build from earlier data-driven efforts to assess local conditions, such as the U.S. Environmental Protection Agency's Smart Growth Index.

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