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Improving Transportation Project Evaluation by Recognizing the Role of Spatial Scale and Context in Measuring Non-User Economic Benefits

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ABSTRACT: The usefulness of transportation project evaluation depends on the completeness of its benefit measures. Since transportation networks are intrinsically spatial, transportation improvement projects have spatial access and location characteristics that can lead to a variety of non-user economic benefits. Recent research has enabled us to better understand how spatial context and spatial heterogeneity play further roles in generating efficiency gains for non-users, in the form of productivity, income, and cost savings for both private and public sectors of the economy. This paper draws upon that body of research to expand our understanding of the means by which transportation projects can generate economic efficiency gains, and approaches needed to measure them. It covers topics beyond those captured by current definitions of "wider economic benefits," including additional sources of scale economies associated with freight distribution and connectivity, and further public and private sector economic gains enabled by environmental and social inclusion improvement. It points to ways that non-user economic benefits can be more comprehensively defined and better measured by recognizing their spatial scale, context, and threshold effects. It also identifies ways that current benefit measurement methods introduce unintended bias into transportation investment decision-making through omission and mismeasurement. The result is a case for a refresh of thinking about how we classify and recognize non-user economic benefits in transportation evaluation, and how we apply transportation planning and economic models to support their measurement.

KEY WORDS: ***economic impact, wider economic benefit, non-user benefit, agglomeration, productivity, connectivity***

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1. INTRODUCTION

1.1 Motivation and Overview

Motivation. In transportation project evaluation today, a distinction is made between direct user benefits and indirect, non-user benefits. Procedures for measuring the former have become, in the main, well defined, but the definition and measurement of the latter is still evolving with continuing shifts in societal values, data availability, and analytic methods.

In this paper, we call attention to the importance of more comprehensively considering economic benefits to non-users in transportation project evaluation. We highlight gaps in currently used measures of economic benefits, and discuss how they can introduce unintended biases in transportation investment decision-making. We make a case for recognizing transportation networks as fundamentally spatial, naturally leading to economic benefits that extend beyond traveler benefits. We then show how a variety of non-user benefits – spanning what are commonly referred to as social, economic, and environmental factors -- can all have effects on the economy and its efficiency -- by generating productivity, income, and/or cost savings for private and public sectors of the economy.

Most critically, we illustrate how non-user benefits are affected by spatial heterogeneity -- context differences among affected areas that interact with their spatial access and proximity characteristics, and create a need to recognize scale and threshold factors. We show how this extends to encompass not only economic benefits of agglomeration, but also environmental and social factors that can also have a direct effect on public and private sector revenues and costs. The implication of these findings is that there is a need for broader consideration of how we define and measure economic benefits, as overly rigid and narrow definitions of these benefits can introduce unintended bias in transportation evaluation and decision-making.

Organization. This paper has four parts. In the rest of section 1, we set the stage by reviewing the historical development, application, and refinement of the non-user economic benefits. This allows us to highlight ongoing definition ambiguities and measurement issues. We then present key findings from recent empirical studies regarding various forms of non-user efficiency benefits, their connection to transportation access, and biases introduced when they are omitted from project evaluation. Section 2 covers these issues for business productivity effects, while Section 3 covers these issues for efficiencies associated with household and government sectors of the economy. Section 4 distills research conclusions to highlight the challenges and opportunities to incorporate non-user economic benefits more broadly in project evaluation.

1.2 Interest in Non-User Benefits: A Brief History and Statement of Need

Evolution of Measurement. Systematic public investment in transportation infrastructure dates back to ancient times. The Romans developed a large system of roads specifically to enable military and economic (trade) expansion. Later, in France, Abbé de Saint-Pierre in 1708 developed a method for comparing benefits and costs of road projects, which explicitly included benefits from increased trade and reduced transportation cost (Jiang, 2021). An early example of benefit cost comparison in the US was the 1826 C&O Canal study, which considered benefits associated with expanded commerce, increased production, and higher land values (discussed in Pearce 1983). The first documented requirement for systematically comparing public benefits and costs was the US Flood Control Act of 1936, which required that henceforth the national government should participate in the improvement of navigable waters only *"if the benefits to whomsoever they accrue are in excess of the estimated costs."* Those benefits included cost savings, as well as tourism and economic development growth (Pierce, 1983).

It was not until the 1960's that welfare economics concepts were refined to make cost benefit analysis (CBA) more theoretically rigorous for project evaluation, following the work of Eckstein (1958), who built upon the concept of utility theory first introduced by Dupuit in 1844. This led to an expansion of CBA's use for transportation project planning and decision-making, but it also created a distinction between user benefit and externality effects. Under the welfare economics paradigm, markets provide a behavioral basis for user benefit valuation based on observation of customer behavior and their willingness to pay for various goods and services. However, markets fail to reflect the full social benefits insofar as there are unpriced "externality' effects on non-users such as environmental impacts, social impacts, or productivity gains from economies of scale. In the transportation planning context, these externality impacts fall outside of the standard valuation of user (traveler) time, cost, and safety benefits.

Interest in externality effects remained strong during this period, leading in 1969 to a US requirement for Environmental Impact Assessment as a way to separately evaluate and assess the broader environmental, social, and economic impacts of proposed projects (US Congress, 1969). Other nations followed shortly thereafter. Researchers have developed several alternative ways to incorporate externality impacts into project evaluation, including extensions of CBA as well as multi-criteria scoring and qualitative business case analysis. The valuation of pollutant emissions became commonly added to transportation CBA starting around 1990. A method for valuing economic productivity based on employment access and agglomeration was added to the UK guidance on transportation appraisal starting in 2006 (UK DfT, 2006a, 2018). More recently, there have been efforts to establish economic benefit values for efficiencies gained by addressing social exclusion and structural unemployment (EBP 2021, Stanley 2022a).

The valuation of non-user benefits and their application in transportation project evaluation is still evolving. While various governments have issued guidance documents that define the measurement of economic benefits, there is a growing body of research on additional economic benefit elements which we describe in this paper. We review a range of these economic externality benefits to highlight common aspects of spatial context, scale, and heterogeneity, and note implications of incorporating them to improve transportation project evaluation.

1.3 Use of Terminology

A clarification of terminology is critical to our case, as there are many ambiguities in the use of nomenclature of economic evaluation for transportation planning. The inset box defines how we use terminology in this paper.

Notes on nomenclature:

- *"Project evaluation" and "project appraisal"* are essentially the same concept. The former is used in North America, the latter in the UK, and both are used elsewhere. We interpret the term *"projects"* in a broad sense since the same evaluation concepts apply to service and program initiatives which do not require building facilities.
- *"Non-User"* impact is a term commonly used by transportation planners. They are sometimes called "*wider*" impacts because they go beyond the traditional measure of traveler impacts. Economists often refer to them as "*externalities*".
- "*Economic Benefit*" can be interpreted as the market value or "willingness to pay" value of all benefits that can be expressed in money terms. However, in this paper we focus primarily on sources of gains in productivity and income, and reductions in operating cost for private or public sectors.
- "*Benefit*" vs "*Impact*" – *Economic Impact* studies may cover positive, negative, and distributional effects on elements of the economy, including effects on specific groups and areas. In contrast, *"economic benefit"* is defined as the aggregate efficiency gain net of all positive, negative, and distributional impacts.

  Note: UK government guidance for transport appraisal has adopted the term "*wider economic benefits" (WEB)* and since replaced it with *"wider economic impacts" (WEI)* to refer to specific economic elements recognized for use in cost benefit analysis within the UK. It represents a narrower benefit definition than that used in this paper --which discusses broader aspects of potential efficiency gains for public and private sectors of the economy. These differences are discussed in Section 4.3.

2. BENEFITS AFFECTING INDUSTRY PRODUCTIVITY

To date, the greatest amount of attention on non-user economic benefits has focused on how access improvements drive business agglomeration and generate productivity gain. We therefore start by reviewing how these effects are analyzed and measured, identifying three types of agglomeration effects. For each, we identify their importance, the body of supporting research, and findings to date.

In this context, productivity gain occurs insofar as businesses benefit from *scale economies* (including scope economies) associated with accessing wider customer markets, labor markets, or supplier markets – which provide a larger, lower cost, and more diverse set of specialized worker skills, specialized materials, and/or customer base. We also discuss the effect of technology on changing the concept of agglomeration. We review research regarding three sources of business-related gain, which apply for different types of projects and contexts.

2.1 *Urban Employment Agglomeration and Productivity*

<u>Importance.</u> Transportation projects can change locational advantage. Physically locating in the center of larger markets maximizes the advantage of scale economies, which is a primary reason why cities and specialized businesses clusters – i.e., agglomerations of economic activity – develop (Venables et al. 2014). Locating in a business cluster within a city can further increase

productivity by enabling closer interaction and greater knowledge sharing among businesses. Regardless of the mechanism driving productivity gain, these are externality effects since the gain in productivity is beyond user benefits. (Krugman 1991, Fujita and Thisse 2002).

Research. While initial research on economic geography focused at the scale of regions and metropolitan areas, recent research has advanced the measurement of employment clustering and its impacts at the local neighborhood level. Since transportation improvements expand markets by shrinking travel times to access surrounding areas, Daniel Graham (2005, 2007) pioneered the concept of "*effective density*" as a measure of business agglomeration at a zonal level. It is calculated as the size of employment in any given industry in any given zone, plus the accessibility-weighted sum of employment in the same industry in surrounding zones. Graham showed how this measure varies by industry and serves as a predictor of zonal differences in productivity, measured in terms of value added per employee. He and other researchers have since refined and validated these findings for areas in the UK, Europe, US, and Australia (Graham et al, 2010, Hensher et al. 2012, Graham and Gibbon 2019, Weisbrod et al 2021). An important common finding is that the financial and business services (office-based activities) have a substantially higher employment agglomeration elasticity, reflecting more spatially concentrated effects on increasing productivity, than other industries such as manufacturing.

Findings. This line of research is notable because:

- It confirms that agglomeration economies exist and can be measured for transportation evaluation. This approach has been incorporated into the UK's CBA guidance, and is now also recognized in other countries.
- It sets a precedent for incorporating spatial economic context in transportation benefit evaluation, since it shows that spatial patterns of travel times interact with the mix and density of surrounding economic activity to affect productivity.

In practice, the inclusion of agglomeration effects following this methodology has the effect of bumping up the benefit-cost ratio for passenger transportation projects that connect employment centers in dense urban contexts. It favors urban passenger projects over those serving freight, intermodal long-distance connections, and access for rural or outlying residential areas. This is due in part to underlying statistical analysis assumptions – that industries achieve productivity by maximizing their effective density of employment, with a decay function for declining returns associated with travel time or distance from the point of maximum density. While those assumptions appear reasonable for office-based services, recent research indicates that other industries optimize agglomeration and scale economies based on factors other than employment concentration. This is explored next.

2.2 Freight-Oriented Agglomeration and Productivity

Importance. While the measurement of agglomeration benefits described above can capture effects of connecting dense employment concentrations, it does not effectively cover freight clusters which occur at differing spatial scales for manufacturing supply chains and distribution industries. We illustrate the forms of "large area" clustering related to logistics and intermodal connectivity, and identify how they enable productivity benefits associated with freight access to broader markets.

Research. Over the past decade, a distinct body of research has grown covering freight agglomeration effects not captured by the previously discussed employment agglomeration approach. Three examples are provided of large area freight-oriented clusters that derive scale economies and thus productivity benefits from transportation systems.

- *Same-Day Manufacturing Supply Chains.* The adoption of "lean manufacturing" maximizes productivity by relying on "just-in-time" delivery in place of inventory stocking. It enables firms to achieve scale economies by locating where they can access wider supplier and delivery markets via same-day delivery, and avoid logistics cost penalties associated with delays. An example is the US Southeastern Automotive Cluster, comprised of assembly plants and parts suppliers clustered an area spanning 600 km. The firms are located near intersections of interstate highways but spaced to avoid traffic congestion and competition for workers (Schulz 2016, Colucci 2017, Karayel 2017, Weisbrod and Goldberg, 2022).
- *Intermodal Freight Connectivity.* For manufacturers and distributors, air and marine terminals represent "gateways" to global markets for incoming parts and outgoing products. This has led to the development of logistics hubs located where there is direct truck access to intermodal terminals, enabling the transfer of freight between regional truck delivery and longer-distance air or sea delivery. An example is the cluster of logistics around Chicago's O'Hare Airport, spanning an area 24 km across. A large volume and value of trade is handled by these facilities, providing scale economies and productivity benefits for consumer and supply chain markets, though the logistics facilities themselves have relatively low employment. (Klaassen et al, 2011, Sheffi 2012, van den Heuvel et al. 2014, Prologis 2015).
- *Regional (Intercity) Distribution Centers*. The rise of same-day and overnight delivery to consumers and businesses is enabled by integrated supply chain management processes with increasingly large regional distribution centers to realize scale economies associated with wider delivery markets (Hesse and Rodrigue 2004, Dablanc et al, 2014). An example is the cluster of distribution centers along a 180 km stretch of US Interstate Highway 81, illustrated below (derived from Weisbrod and Goldberg 2022). Growth in working from home has further increased distribution center activities associated with online orders, as delivery via light commercial vehicles has replaced some passenger shopping trips (Adibfar et al 2022, Said et al. 2023).

In each of these examples, manufacturing and distribution firms cluster (agglomerate) in ways that *optimize* network connectivity rather than *maximize* agglomeration density. Each is configured to take advantage of proximity to highway nodes and intermodal facilities to expand same-day market access and achieve scale economies, while locating in outlying areas to maintain reliability by minimizing delays from traffic congestion. The result is that they appear clustered along major transportation routes when viewed from a wide area perspective (illustrated in Figure 1A) but appear spatially spread when we zoom in to a small area perspective (illustrated in Figure 1B). This phenomenon is illustrated with a US example, but also occurs around the world. It explains why manufacturing and distribution industries appear to have relatively weak spatial agglomeration when viewed in terms of the previously discussed "effective density" measures, which are typically based on small area zones. This highlights the importance of adopting a measurement scale that is most relevant to capture network connectivity effects for freight agglomeration.

(A) Wide Area Perspective *(B) Close up Perspective*

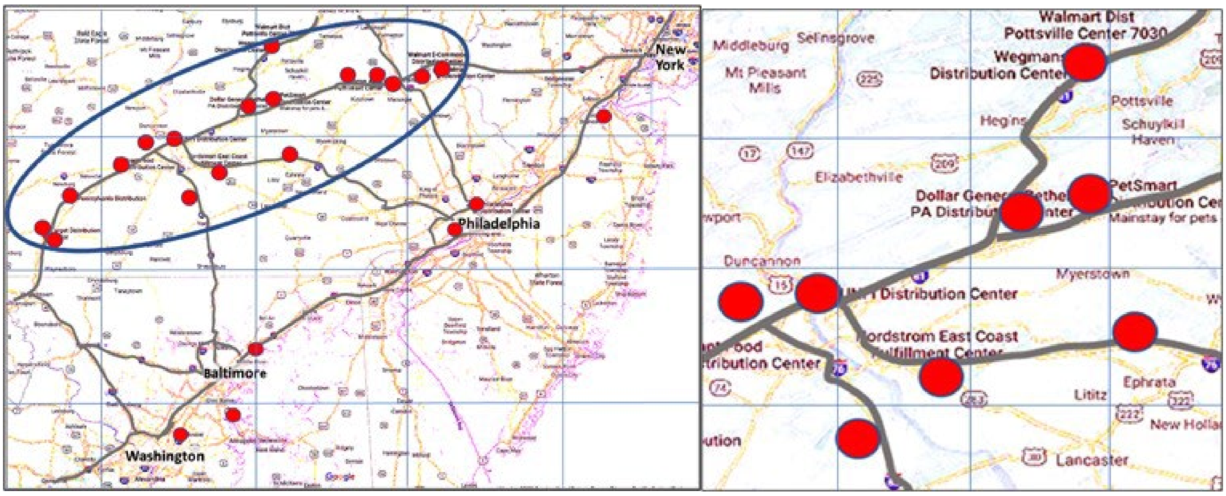


Figure 1: Distribution Centers in Southeastern Pennsylvania
Source: Weisbrod and Goldberg, 2022

This finding has been confirmed by comparing how industrial and distribution industry clustering and wage rate effects appear differently when viewed using small traffic analysis zones within a metropolitan area, compared with a similar analysis using a larger scale county-level zone system (See Table 1). In that case, statistical analysis showed stronger clustering and productivity relationships for manufacturing and distribution activities when viewed in terms of broader-scale regional market and intermodal access metrics, while retail and producer services are stronger than other zones when viewed using small zone effective density metrics. (See highlighted coefficients in the table). These differences can reflect spatial heterogeneity which requires use of relevant spatial zone levels for applicability to different industries.

Table 1 Agglomeration Effect on Wage Rates Using Small Area vs. Wide Area Views

Industry	Elasticity of Wage Rate Gain* From Greater Industry Agglomeration		
	Small Zone: Effective Density Measure (A)	Large Zone: Market Scale Measure (B)	Large Zone: Intermodal Terminal Access (B)**
Manufacturing	0.026	**0.041**	**0.095**
Distribution/Other	0.020	<0.001	**0.086**
Retail/Consumer Services	**0.072**	<0.001	0.000
Producer/Business Services	**0.062**	0.008	**0.281**

**Wage rate is used as the indicator of greater value productivity, based on US data*
***Intermodal terminal access is based on time to airport (seaport for bulk manufacturing)*
(A) from Weisbrod et al 2021, (B) from Weisbrod and Goldberg 2022

Findings. Research on freight access and clustering provides the following insights:

- It demonstrates the importance of freight access and agglomeration, in addition to passenger (employee) access and agglomeration, as generators of scale economies and productivity gain.
- It shows that agglomeration and clustering of business activities can occur at different spatial scales and densities depending on the industry. This indicates that productivity optimization can be tied to industry technology requirements, and that calls for alternative views of clusters and market potential based on *market connectivity* in addition to the current use of effective density. One could, for instance, construct a freight connectivity network measure based on travel model logsums (Vadali et al, 2017).
- It reinforces the need to recognize spatial-economic context in transportation benefit evaluation, since it shows the importance of considering locations relative to transportation nodes and intermodal facilities.

These findings indicate a need to recognize productivity benefits associated with manufacturing, supply chain, and distribution activities in transportation project evaluation at an appropriate spatial scale. Doing so will provide a means for better recognizing benefits associated with projects connecting to distribution centers, intermodal facilities, and manufacturing activities in peripheral and rural areas. Failure to do so may unintentionally skew transportation investment decisions away from investment supporting freight movement in outlying areas.

2.3 Virtual (Digital) Agglomeration and Productivity

Importance. The discussion so far has covered relationships between the location of business activities and their spatial access characteristics. These relationships are likely to be changing in the future as information technologies are enabling both more remote work in lieu of in-person commuting and greater ease of doing business anywhere. Growing reliance on digital information connectivity reduces the benefits of physical density as well as spatial proximity benefits for office-oriented industries such as finance, insurance, and other producer services. There is a growing body of research on virtual agglomeration (e.g., see Liu et al 2020, Chen et al 2021).

Research. The COVID pandemic accelerated adoption of an already emergent technology enabling remote working. Even with post-COVID readjustment, it is clear that there is a long-term trend of increasing remote working (Vincenzi 2022), especially for computer-based office activities (McKinsey 2021). Ramani and Bloom (2021) measured associated changes in migration patterns and real estate markets within and across US cities. They found that within large US cities, evidence of a consistent shift in household, business, and real estate location demand from dense central business districts towards lower density suburban districts.

Digital agglomeration effects have also been observed in studies with supporting evidence from employers that productivity has increased as a result of increased working from home (Hensher et al 2022). Perceived productivity has a strong correlated link to economic productivity as shown by Barro et al. (2021), who found that data on employer plans and the relative productivity of working from home implied a 5 percent productivity boost in the post-pandemic economy due to re-optimized working arrangements. Only one-fifth of this productivity gain will show up in conventional productivity measures, because they do not capture the time savings from less commuting. At the same time, digital agglomeration is driving the growth of e-commerce, increasing goods deliveries to dispersed residential sites and increasing economies of scale for distribution industries (Australia Post 2022).

Findings. This line of research is important in showing that scale economies may come not only from physical agglomeration, but also from connectivity to transportation and information networks. It also suggests that in the future, the physical agglomeration and transportation connectivity benefits underlying "effective density" are likely to become even further dependent on the coexistence of "virtual agglomeration" via employee connectivity to high-speed information networks at a region-wide level. All three can interact to affect value creation for various elements of the economy. By recognizing these conditional relationships, further priority may be given to projects that improve the speed and capacity of both regional internet and regional delivery facilities. Conversely, by failing to recognize these spatial-economic context factors, transportation investment decisions may be unintentionally skewed away from projects that facilitate future economic growth in industries that depend on both information technology and goods movement.

3. BENEFITS AFFECTING HOUSEHOLDS AND PUBLIC WELFARE

Section 2 showed how access and connectivity improvements can lead to private sector productivity gain. It focused on business access rather than household access because the household sector of the economy does not itself produce economic products, and hence cannot generate value added and gain productivity. However, improving access for households can still generate public welfare gains that have real economic benefits as well as efficiency value in the form of cost savings for government and households. We review three forms of this effect, which are additive to user benefits.

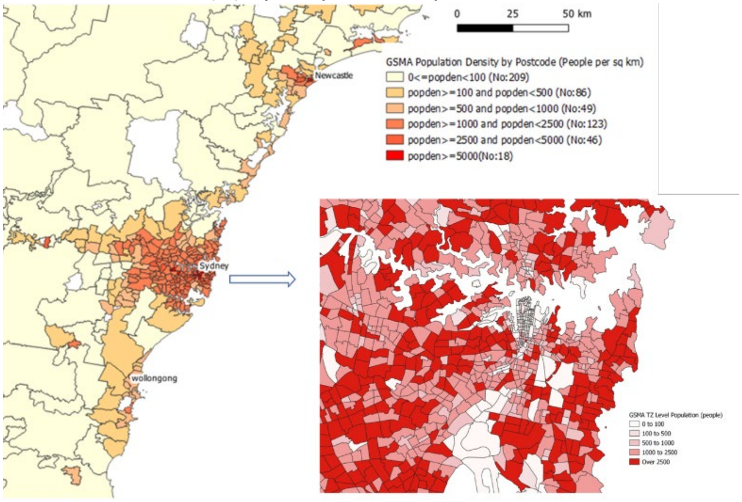
3.1 Labor and Job Market Access: Economic Efficiency Gains

Importance. Section 2 addressed agglomeration and access between similar and complementary businesses, but it did not address the potential benefit of transportation projects that improve access to and from residential areas. This can be particularly important for projects that enhance access between outlying residential areas and business activity centers, which can have scale economies by expanding the size of labor market access for employers and enlarging job market access for residents.

A key differentiator for population and associated labor markets is the spatial scale at which they agglomerate. Seen from a wide regional view, both population and employment have similar spatial concentrations at the metropolitan level (see left side maps in Figure 2). However, *within* any specific metropolitan area, population can be seen as highly dispersed while employment is concentrated in specific business centers (shown in right side maps in Figure 2). While this is illustrated for Sydney, Australia, this same basic concept holds for essentially all urban areas.

These patterns reflect the common household location preference for a reasonable journey to work (e.g., typically within a 40 to 60-minute travel time threshold, which typifies the scale of most metropolitan areas), with far less concern for minimizing commute time within that threshold. This occurs because personal location preferences and housing cost factors emerge as important factors for residential location within metropolitan (labor market) area. Thus, concepts of "sufficiency of worker access to jobs" and "sufficiency of employer access to workers" may be viewed in terms of the scale of available choices within a time threshold.

(A) Sydney Area Population



(B) Sydney Area Employment

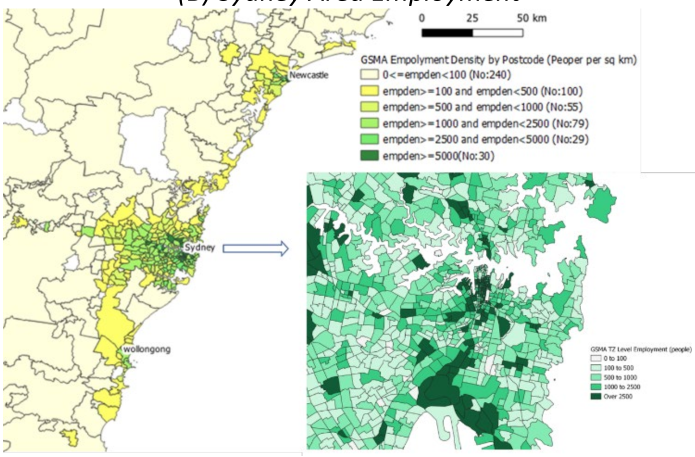


Figure 2: Differing Population + Employment Distributions in a Metropolitan Area: Sydney, Australia. (Source Institute of Transport and Logistics Studies (ITLS) mapping)

<u>Research.</u> We identify two potential sources of non-user economic benefits that depend on the scale of home-work market access opportunities.

- *Business Productivity from Improved Skill Matching.* From a business perspective, improving surface transportation routes and services from urban activity centers to outlying communities can effectively enlarge the available labor market. That has been shown to be most important for high tech industries and tech-reliant producer services, which can gain productivity from accessing a larger labor pool to get more highly differentiated and specialized skills, particularly when in areas with high education levels and a major research university (Meeks and Hassink 2019, Kerr and Robert-Nicoud 2020, Zandiatashbar 2021). Because of the importance of skill matching, these industries tend to pay more and attract workers from a longer distance than other industries within the labor market area. As a result, increasing scale of the available labor market is associated with higher wages, which is presumed to reflect higher productivity. Weisbrod et al (2021) confirmed this higher wage effect for producer services, by comparing the elasticity of wage rate with respect to population within a 45-minute commuting time for various industry categories.

- *Reducing Structural Unemployment in Isolated Areas.* A second source of non-user economic benefit can be reduced cost to government associated with involuntary unemployment (or under-employment). From a public perspective, improving connectivity from economically distressed rural areas to more affluent urban activity centers (see Mulley et al. 2023) can potentially bring efficiency gains by reducing public funding needs for unemployment and income assistance payments. This applies particularly for isolated areas where access to job opportunities is limited, but new road or rail routes as well as passenger transportation and internet improvements can expand opportunities for employment with livable wages. For example, the Appalachian Development Highway System was initiated in the US to promote access to markets and expand job opportunities for residents of isolated mountain areas that had formerly relied on coal and other resource extraction industries. Ex post studies have credited it with reducing poverty there (CREC 2015, EDRG, 2016).

  In economic terms, access to adequate income and living conditions is a "quasi-public good." In that context, public expenditure for income support and poverty reduction programs demonstrates societal "willingness to pay" for provision of that desired good for those who are otherwise unable to access or achieve it privately. A social welfare benefit can be achieved by saving public program expenditures to the extent that transportation improvement reduces the incidence of unemployment and poverty. A regional economic model can calculate the net impact on employment and poverty reduction, and the public cost savings benefit can be calculated from average per capita program expenditures. For example, annual US federal government spending on welfare programs amounts to around $30,000 per person living in poverty (Grozdanov, 2022). Of course, care is required to appropriately recognize the dependency of transportation improvement impacts on concurrent support programs (such as job training).

  This use of public expenditures as a basis for establishing willingness to pay for public goods has been recognized in the concept of an expanded CBA for intercity rail in the US, called "Business Case ROI" (EBP 2021). While one can criticize the current willingness to pay for public programs as undervaluing social benefits, the counter argument is that this is better than totally omitting these benefits from CBA since they are increasingly being shown to be non-marginal (Stanley et al. 2022a).

<u>Findings.</u> The literature cited above points to ways that improved road and rail connections between urban areas and outlying communities can generate economic efficiency gains. There is an important reason to recognize these forms of economic benefit, which is that is that they can apply to a class of projects that may otherwise be left out of economic benefit calculations.

3.2 Social Inclusion: Value of Public Benefits

<u>Importance.</u> While providing travel opportunities for transportation disadvantaged people has long been a primary reason for provision of public transportation services, including dedicated community transport services, social inclusion benefits are most commonly recognized as a

social impact to be considered in qualitative terms but excluded from CBA. However, an emerging body of research has identified the social welfare loss incurred by low income and elderly households, including individuals with a disability, who are mobility constrained and live in areas with limited public transportation access. Other reports have documented the societal and government costs of programs aimed at ameliorating this disadvantage.

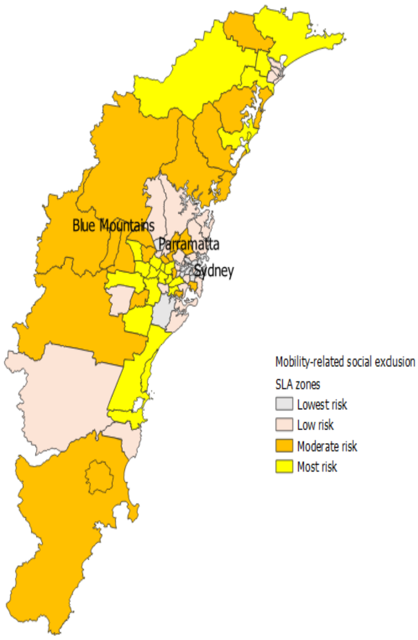
The omission of social inclusion benefits from CBA has important implications for planning and policy settings where the decision-making process utilizes cost benefit comparisons to inform the evaluation of alternative initiatives. The omission can effectively (if unintentionally) entrench biases against public transportation or other appropriate modal measures that might reduce social exclusion risk and associated social costs. Also to note, social inclusion is related to notions of liveability, well-being, and quality of life; however, the distinguishing factor is that social inclusion implies deficiency thresholds that can be used to establish personal and societal costs to ameliorate, which we need for CBA.

<u>Research.</u> A pioneering report of the UK government's Social Exclusion Unit (2003) cited statistics on the breadth and consequences of constraints on access to work, learning, healthcare, food shops and social activities. Subsequent studies documented transportation access deficiencies in the UK, US, and Australia, and reviewed public efforts to address them (Lucas, 2012). Later studies have documented relationships between modal accessibility disparities and social exclusion (Lunke 2022).

Stanley et al. (2011, 2022a) showed how it is possible to monetize the welfare costs of social inclusion deficiencies for inclusion in CBA, through social valuation of additional trip-making by those who were mobility constrained and hence at higher risk of further social exclusion. This approach was subsequently applied in Australian cost-benefit studies for proposed public transportation projects including the Melbourne area's Suburban Rail Loop (KPMG 2021), Sydney west area bus, and Parramatta Light Rail (Stanley et al. 2022b). The latter study demonstrated how social inclusion benefits can be monetized using available planning data to link variation in household income, access, trip-making, and exclusion risk levels.

This line of analysis, as cited above, builds on three fundamental elements. (1) Survey research has documented social exclusion impacts in terms of deficiencies in reported levels of personal well-being, sense of community, bonding capital (strength of close networks) and bridging capital (strength of wider networks) (Stanley et al., 2022b). (2) Levels of these deficiencies have been combined into social exclusion risk ratings, the incidence of which correlates strongly with low-income indicator of disadvantage and risk of social exclusion, and age-related mobility dependence (reflecting dependence of children and older people on public transportation and ride services). (3) The spatial incidence of these factors can be mapped. Figure 3 illustrates the spatial incidence of mobility-related social exclusion ratings among zones in a metropolitan area.

Figure 3: Mobility-Related Risk of Social Exclusion, Sydney Metro Area (Stanley et al, 2022a)



Further analysis has shown that social exclusion is highest in zones where public transportation services are also least available. Finally, the benefit of enabling more trip-making by increasing public transportation service can be monetized, with the value of that benefit increasing as household income declines (Stanley et al. 2011a, 2022b). The benefit is based on estimates of the willingness to pay (or marginal rate of substitution) estimate for additional trips, which can be considered a proxy for societal externality costs of social inclusion deficiencies (e.g., public costs of deficiencies in physical and mental health, education, poverty, or the opportunity cost of social programs aimed at ameliorating them). Bolstering this interpretation, the value of an additional trip to reduce social exclusion has been shown to be significantly above the "rule of half" valuation for induced trip-making in a travel demand model, suggesting that those trips are not marginal and reflect the value of the additional activity enabled by them.

Findings. Methods developed by past research and their recent applications open the possibility of including the value of social inclusion benefits as part of the assessment of any major transportation initiative that enhances access and mobility to populations or areas that are otherwise deficient in that regard. It provides a means of reducing bias against public transportation improvements intended to reduce exclusion risk, that otherwise come out poorly in CBA due to lack of monetizable benefits.

The research further demonstrates pathways by which social exclusion can be reduced in a land use transportation setting. This is significant, as it shows that risk of social exclusion is influenced by a number of factors involving household characteristics and the level of disadvantage of the spatial setting or context -- information that is readily available to planners.

Since social exclusion can be correlated with both low income and isolation, care is required to avoid overlap if income-based distributional weighting is also adopted, or if there is also an accounting of effects related to costs of structural unemployment in isolated rural areas. However, social exclusion is clearly far more than those two elements, as it is very much related to the spatial context of transportation access and opportunity.

3.3 Environmental Cost Reduction as a Source of Economic Benefit

Significance. While planners often distinguish environmental impacts from economic impacts, environmental benefits can in fact translate into *economic benefits* insofar as they involve changes in health care costs, physical damage costs, and loss of income incurred by households and businesses. Furthermore, the severity of pollution costs can also vary by the spatial context of population and employment patterns, in the same way that agglomeration and access benefits vary by spatial context. The main difference is that the benefit of reduced environmental damage is more directly related to spatial proximity than spatial accessibility.

Research. Conventional CBA often includes emissions reduction benefit calculations based on transportation measures (e.g., mode, volume, distance, speed) and unit factors for pollution (damage, abatement) costs, in a manner similar to the calculation of travel cost reduction benefits. So just as travel cost benefit is based on constants for costs per vehicle-hour and vehicle-km traveled, emissions benefit calculations are often based on constants for emissions per vehicle-km and cost/ton (allowing for vehicle type, speed, and distance from roads). However, that approach can introduce bias by missing local context factors like local population and business characteristics, which can increase pollution damage cost in urban areas and reduce it in rural areas (Daniels and Hensher 2000, US EPA 2014).

Findings. Failure to account for spatial context and its economic implications can skew environmental benefit evaluation, to understate pollution costs in urban areas and overstate them in rural areas. A more context-sensitive form of evaluation - as done for agglomeration and access benefits – can minimize this potential bias. This does not apply to greenhouse gas emissions, as their impacts are global and cumulative over time, and thus are not skewed by spatial heterogeneity.

4. SYNTHESIS OF FINDINGS

4.1 Common Features of Non-User Economic Benefits

In the prior sections, we catalogued various economic benefits that can arise from the effects on non-users. They emerge from a body of recent research which is expanding the recognized range of possible externality effects that can lead to economic efficiency gains for business, household, or government sectors of the economy. As the range of potential non-user economic benefits is expanded, historic distinctions between social, economic, and environmental externalities can become less clear and less useful.

Altogether, our review of them leads to three key findings:

(1) The non-user economic benefits reviewed here have the common feature that they all derive from spatial impacts of transportation projects on non-users. As a result, all are affected by the interaction of projects with the spatial context of affected areas -- in terms of their business patterns, socio-economic patterns, or physical settings. That makes spatial context a central factor affecting the magnitude of non-user economic benefits, and one that differentiates them from user benefits (which are independent of spatial context). However, they do differ in terms of whether the non-user benefits accrue from changes in spatial access (e.g., business agglomeration), or spatial proximity

(e.g., environmental damages), or spatial connectivity (e.g., virtual agglomeration using information data technology).

(2) Non-user economic benefits can occur at different spatial scales, with some becoming most apparent when viewed from a wide area perspective (e.g., freight supply chain agglomeration) and others becoming most apparent when viewed from a close-up perspective (e.g., urban business agglomeration).

(3) The functional form of spatial impact can differ. Some non-user economic benefits can be best defined and measured by a gravity-type decay function that reflects diminishing economic value as proximity or accessibility becomes smaller. Others can be best defined and measured by recognizing an access sufficiency threshold. Examples of the former include business agglomeration effects. Examples of the latter include same-day freight delivery markets and metropolitan labor markets. Social exclusion also involves a sufficiency concept.

4.2 Discussion: Potential for Bias in Decision-Making

There is reason for fearing systematic bias in how economic benefits are currently measured and valued in transportation project evaluation. Bias comes from failure to recognize that benefits can occur for different sectors of the economy at different spatial scales, which also depend on considerations of their technologies, modes, and application contexts. This is summarized in Table 2, which shows the differing types of access effects covered in this paper, and how their effects are most applicable for different travel modes and types of impact areas.

Table 2. Relationship of Different types of Access Benefits to Modes and Impact Areas

Access Mechanism for Creating Efficiency Gain*	Primary Benefitting Areas	Main Modes of Benefit				
		Car	Public Trans	Truck	Intercity Train	Inter-net
Urban Agglomeration (A)	urban business centers	X	X	-	X	-
Freight Agglomeration (A)	rural + outlying highway corridors	-	-	X	-	-
Virtual Agglomeration (A)	isolated rural areas	-	-	-	-	X
Labor Market Access (B)	Isolated, outlying areas	X	-	-	X	-
Social Inclusion (B)	Urban, low-income neighborhoods	-	X	-	-	-

* *Efficiency occurs through mechanisms of: (A) productivity gain, (B) social/public cost reduction*

Note: the table omits active transportation modes (bicycling, walking) because those modes are not generally associated with expanding spatial access though they do bring health, safety, and pollution reduction benefits

The preceding table has important implications. Current practice most often either ignores these non-user benefits or at most just covers urban agglomeration benefits. Either way can introduce a bias that gives advantage to passenger transportation projects benefitting access to urban business centers. By adding recognition of freight agglomeration, the case is strengthened for support of truck and rail freight corridors including rural areas. By adding recognition of potential labor market and social inclusion benefits, the case may be strengthened for supporting public transportation and passenger train services.

4.3 Contrast to the Concept of "Wider Economic Benefits"

The UK's Transport Appraisal Guidance (WebTAG) provides a very specific, prescriptive methodology for defining and measuring "wider economic benefits" (or "wider economic impacts") for project appraisal in Britain. That concept differs from the non-user economic benefits discussed in this paper in two ways:

- It is narrower in that it recognizes scale economies associated with employment agglomeration but not productivity associated with freight agglomeration or technology skill matching, or public savings associated with structural unemployment and social exclusion. It is also narrower in that it places the value of environmental and social benefits outside of the category of economic benefits.
- It is broader in that it includes technical adjustments for welfare benefits associated with imperfect competition including (a) output growth due to cost changes associated with land use shifts, and (b) tax revenue to government resulting from higher business output enabled by increased labor market participation. These effects are theoretically sound, but are not discussed here as there is a dearth of empirical research supporting their incidence and links to spatial heterogeneity.

5. Conclusion: Improving Project Evaluation and Economic Benefit Calculation

One of the factors limiting the broader adoption of non-user economic benefits in transportation project evaluation is the rigidity of conventional travel demand models that lack information on local demographic and economic context factors that are most relevant for measuring non-user benefits. With the growth of spatially disaggregated databases, there are expanding opportunities to improve travel demand and economic benefit calculations. However, rigid modeling standards imposed by government agencies can reduce incentive for planners to innovate in model improvements that could make it easier to incorporate non-user economic benefits into transportation evaluation.

Technology Innovation also plays a role in changing non-user economic benefits and requirements for their measurement. For example, information technology advances are enabling growth of just-in-time supply chains as well as "virtual agglomeration", and changing in the importance of access for goods delivery as well as commuting. In this context, there are clear dangers in continued reliance on conventional models that forecast into the future with a calibrated reference base that is no longer suitable for a world of changing technology and shifting transportation system use patterns. The consequences extend beyond error in calculating user benefits. They also undermine the capability to measure spatial access effects that underly some of the economic benefits covered in this paper.

In recent years, substantial progress has taken place in expanding the monetization of spatial access benefits and improving the modeling of public cost reduction benefits. New research can improve the calibration of job, workforce, and goods delivery access measures -- in terms of their spatial scale, time-based threshold and decay factors, and context variation – including mode, purpose, and industry or socioeconomic group. Further research can also improve our understanding of how physical and virtual agglomeration interact to create economic value.

The ability to identify the appropriate spatial scale in representing the true level of benefit for each and every heterogeneous benefit -- user and non-user -- should be possible with advanced computing and data processing algorithms. Finally, the calculation of non-user economic benefits can also be improved through *ex post* analysis to better measure the magnitude and value of cumulative effects as technology evolves.

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References

Adibfar, A., Gulhare, S., Srinivasan, S., Costin, A. (2022) Analysis and modeling of changes in online shopping behaviour due to Covid-19 pandemic: A Florida case study. *Transport Policy* 126, 162-176.

Anable, J. and P. Goodwin (2021) *Two Futures: Transport Policy, Planning and Appraisal for the New Climate Reality*.

Australia Post (2022). *Inside Australian Online Shopping - eCommerce Industry Report*.

Barrero, J.., N. Bloom, S. Davis (2021). Why Working from Home Will *Stick, NBER Working Paper 2873*.

CREC: Centre for Regional Economic Competitiveness (2015). *Appalachia Then and Now*, Appalachian Regional Commission, Washington DC. https://www.arc.gov/wp-content/uploads/2020/06/AppalachiaThenAndNowCompiledReports.pdf

Chen, X., G. Changchun, Y. Jiang (2021). Mechanism Underlying the Formation of Virtual Agglomeration of Creative Industries: Theoretical Analysis and Empirical Research, *Sustainability* 2021, 13(4); https://doi.org/10.3390/su13041637

Colucci, J. (2017). *Strengths, Uniqueness and Synergies Across the Southeast, Manufacturing Innovation Blog*. National Institute of Standards and Technology (NIST) https:// www.nist.gov/blogs/manufacturing-innovation-blog/ strengths-uniqueness-and-synergies-across-southeast.

Dablanc, L., S. Ogilvie, A. Goodchild (2014). Logistics Sprawl: Differential Warehousing Development Patterns. *Transportation Research Record,* 2410: 105–112.

Daniels, R. and Hensher, D.A. (2000) Valuation of Environmental Impacts of Transportation Projects: The Challenge of Self-Interest Proximity, *Journal of Transport Economics and Policy*, 34(2), May, 189-214.

EBP (2021). *Assessing the Business Case ROI for Intercity Passenger Rail Corridor Investments, Vol. 2 Methodology*, American Public Transportation Association (APTA) and American Association of State and Highway Transportation Officials (AASHTO).

Eckstein, O. (1958). *Water Resource Development: The Economics of Project Evaluation*, Harvard University Press.

EDRG: Economic Development Research Group (2016). *Economic Analysis of Completing the Appalachian Development Highway System*, Appalachian Regional Commission. https://www.arc.gov/wp-content/uploads/2020/06/ADHSEconomicAnalysisTechnicalReportJuly2017.pdf

Fujita, M. and J. Thisse (2002). *Economics of Agglomeration: Cities, Industrial Location, and Globalization*, Cambridge University Press

Graham, D. J. (2005). *Wider economic benefits of transport improvements: link between agglomeration and productivity, Stage 1 Report*. London: DFT.

Graham DJ (2007). Agglomeration, productivity and transport investment' *Journal of Transport Economics and Policy*, 41, 317-343.

Graham, D., S. Gibbons, and R. Martin (2010) The spatial decay of agglomeration economies: estimates for use in transport appraisal, Final Report, Imperial College London.

Graham, D. and S. Gibbons (2019). Quantifying Wider Economic Impacts of agglomeration for transport appraisal: Existing evidence and future directions, *Economics of Transport*, 19

Grozdanov, A. (2022). Important Welfare Statistics for 2022, Lexington Law. https://www.lexingtonlaw.com/blog/finance/welfare-statistics.html

Hensher, D., T. Truong, C. Mulley, R. Ellison (2012). Assessing the wider economy impacts of transport infrastructure investment with an illustrative application to the North-West Rail Link project in Sydney, Australia, *Journal of Transport Geography*, 24: 292-305.

Hensher, D., E. Wei, M. Beck (2022). The Impact of COVID-19 and working from home on the main location office space retained and the future use of satellite offices *Transport Policy*, 130, 184-195.

Hesse, M., and J. Rodrigue (2004). The Transport Geography of Logistics and Freight Distribution. *Journal of Transport Geography*, 12: 171–184. https://doi. org/10.1016/j.jtrangeo.2003.12.004.

Jiang, W. and R. Marggraf (2021). The origin of cost–benefit analysis: a comparative view of France and the United States, *Cost Effective Resource Allocation*, 19 (74) https://doi.org/10.1186/s12962-021-00330-3

Karayel, S. (2017). Power of Automotive Supplier Cluster: The Case of BMW in South Carolina. *European Scientific Journal: 13 (4)*. https://doi.org/10.19044/ esj.2017.v13n4p87.

Kerr, W., and F. Robert-Nicoud. (2020). Tech Clusters. Working Paper 20-063. Harvard Business School, Boston. https://www.hbs.edu/ris/Publication%20Files/20-063_97e5ef89-c027-4e95-a462-21238104e0c8.pdf .

Klaassen, H., P. M. J. Warffemius, and A. I. J. M Van der Hoorn (2011). Modeling the Clustering of Distribution Centres Around Amsterdam Airport Schiphol. *Journal of Airport Management*, 4 (3): 265–279

Krugman, P. (1991). "Increasing returns and economic geography," *Journal of Political Economy*, 99, 483-499.

Le, HTK., A. Carrel, H. Shah (2022). Impacts of online shopping on travel demand: a systematic review. *Transport Reviews* 42, 273–295.

Liu, S., W. He, X. Chen, J. Xie (2020). Virtual Agglomeration of Producer Services and the Changing Geography of Innovation Systems: Implications for Developing Countries, *Journal of Service Science and Management*, 13, 408-419, https://doi.org/10.4236/jssm.2020.132027

Lucas, K. (2012). Transport and social exclusion: Where are we now?, *Transport Policy*, 20, 105-113. https://doi.org/10.1016/j.tranpol.2012.01.013.

Lunke, E. (2022). Modal accessibility disparities and transport poverty in the Oslo region, *Transportation Research Part D*, 103.

Maltese, I., M. Pira, E. Marcucci, V. Gatta, C. Evangelinos (2021). Grocery or @grocery: A stated preference investigation in Rome and Milan. *Research in Transportation Economics* 87, 1-12.

McKinsey Global Institute (2021). The Future of Work After COVID-19, McKinsey and Co. https://www.mckinsey.com/featured-insights/future-of-work/the-future-of-work-after-covid-19

Meeks, J. and W. Hassink (2019). Endogenous Local Labour Markets, Regional Aggregation and Agglomeration Economies, Discussion Paper IZA DP 12765, IZA Institute of Labour Economics, Bonn.

Mulley, C., Nelson, J.D., Ho, C and Hensher, D.A. (2023) MaaS in a regional and rural setting: recent experience, *Transport Policy*, 133, 75-85.

Pearce, D.W. (1983). The Origins of Cost-Benefit Analysis. In: Cost-Benefit Analysis. Studies in Economics. Palgrave, London. https://doi.org/10.1007/978-1-349-17196-5_2

Prologis (2015). *The Evolution of Logistics Real Estate Clusters*. Supply Chain / Global, August. https://www.prolo-gis.com/logistics-industry-research/evolution-logistics-real-estate-clusters

Ramani, A., and Bloom, N. (2021) The Donut Effect of COVID-19 on Cities, *NBER Working Papers 28876*, National Bureau of Economic Research, Inc. https://www.nber.org/system/files/working_papers/w28876/w28876.pdf

Said, M., Tahlyan, D., Stathopoulos, A., Mahmassani, H., Walker, J., Shaheen, S. (2023) In-person, pick up or delivery? Evolving patterns of household spending behaviour through the early reopening phase of the COVID-19 pandemic. *Travel Behaviour and Society* 31, 295-311.

Social Exclusion Unit. (2003). Making the Connections: Final Report on Transport and Social Exclusion, UK Office of the Deputy Prime Minister, London. https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_policy/---invest/documents/publication/wcms_asist_8210.pdf

Schultz, B. (2016). The Rise of the Southern Automobile Industry. *City Data*. https://www.city-data.com/blog/619-rise-southern-automobile-industry/#ixzz7DM89ZDy3

Sheffi, Y. (2012) *Logistics Clusters*. MIT Press, Cambridge, MA

Stanley, J, Hensher, D, Stanley, J, Currie, G, Greene, W, Vella-Brodrick, D (2011) Social exclusion and the value of mobility. *Journal of Transport Economics and Policy* 45(2), 197-222.

Stanley, J., Stanley, J., Hansen, R. (2022). *How Great Cities Happen: Integrating People, Land Use and Transport*. Cheltenham: Edward Elgar Publishing.

Stanley, J., Hensher, D.A., Wei, E., and Liu, W. (2022a) Major urban transport expenditure initiatives: where are the returns likely to be strongest and how significant is social exclusion in making the case. *Research in Transport Business and Management*, 43, 100731

Stanley, J.K., Hensher, D.A. and Stanley, J.R. (2022b) Place-based disadvantage, social exclusion and the value of mobility, *Transportation Research Part A,* 160, 101-113.

UK Department for Transport (2006a). Transport, Wider Economic Benefits and Impacts on GDP.

UK Department for Transport (2018). TAG (Transport Appraisal Guidance), Unit A2.1, Wider Economic Impact Appraisal, Dept. for Transport, London https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/955343/tag-unit-a2-1-wider-impacts-overview-document.pdf

US Congress (1969). National Environmental Policy Act of 1969 (NEPA) 42 U.S.Code, section 4321

US Environmental Protection Agency (2014). Near Roadway Air Pollution and Health: Frequently Asked Questions, Office of Transportation and Air Quality EPA-420-F-14-044

Vadali, S, C. Kruse, k. Kuhn, A.Goodchild (2017). Guide for Conducting Benefit-Cost Analyses of Multimodal, Multijurisdictional Freight Corridor Investments. Washington, DC: National Academies Press. https://doi.org/10.17226/24680

van den Heuvel, F., L. Rivera, K. Van Donselaar, A. de Jong, Y. Sheffi, P. de Langen, and J. Franso (2014). Relationship Between Freight Accessibility and Logistics Employment in US Counties. *Transportation Research Part A: Policy and Practice*, 59 (1), 91-105. https://doi. org/10/10.1016/j.tra.2013.11.002.

Venables, A., J. Laird, H. Overman (2014). Transport investment and economic performance: Implications for project appraisal, prepared for UK Dept. for Transport, White Rose University Consortium. https://eprints.whiterose.ac.uk/83528/1/Venables%2C%20Laird%20and%20Overman%20%282014%29%20TIEP_Report.pdf

Vincenzi, C., M. Pansini, B. Ferrara, I. Buonomo, P. Benevene (2022). Consequences of COVID-19 on Employees in Remote Working: Challenges, Risks and Opportunities An Evidence-Based Literature Review, *International Journal of Environmental Research and Public Health*. 19(18): 11672. https://doi.org/10.3390/ijerph191811672

Weisbrod, G., J. Goldberg, and P. Frank (2021). Measuring the Regional Economic Impact of Transportation Access Improvements in the Context of a Large Metropolitan Region. *Transportation Research Record* 2675: 417–427. https://doi.org/10.1177/03611981211002520

Weisbrod, G. and J. Goldberg (2022). Relationship of Regional, Freight, and Intermodal Market Access to Industry Location and Productivity, *Transportation Research Record.* https://doi.org/10.1177/03611981221131306

Zandiatashbar, A., and S. Hamidi (2021). Transportation Amenities and High-Tech Firm Location: An Empirical Study of High-Tech Clusters. Transportation Research Record, 2675: 820–831.