



70206

GOING BEYOND TRAVEL-TIME SAVINGS



ROBERT CERVERO

©2011 The International Bank for Reconstruction and Development / The World Bank
1818 H Street NW
Washington DC 20433
Telephone: 202-473-1000
Internet: www.worldbank.org
E-mail: feedback@worldbank.org

All rights reserved

This volume is a product of the staff of the International Bank for Reconstruction and Development / The World Bank. The findings, interpretations, and conclusions expressed in this volume do not necessarily reflect the views of the Executive Directors of The World Bank or the governments they represent.

The World Bank does not guarantee the accuracy of the data included in this work. The boundaries, colors, denominations, and other information shown on any map in this work do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

Rights and Permissions

The material in this publication is copyrighted. Copying and/or transmitting portions or all of this work without permission may be a violation of applicable law. The International Bank for Reconstruction and Development / The World Bank encourages dissemination of its work and will normally grant permission to reproduce portions of the work promptly.

For permission to photocopy or reprint any part of this work, please send a request with complete information to the Copyright Clearance Center Inc., 222 Rosewood Drive, Danvers, MA 01923, USA; telephone: 978-750-8400; fax: 978-750-4470; Internet: www.copyright.com.

All other queries on rights and licenses, including subsidiary rights, should be addressed to the Office of the Publisher, The World Bank, 1818 H Street NW, Washington, DC 20433, USA; fax: 202-522-2422; e-mail:

pubrights@worldbank.org.

GOING BEYOND TRAVEL-TIME SAVINGS: AN
EXPANDED FRAMEWORK FOR EVALUATING
URBAN TRANSPORT PROJECTS



The Transport Research Support program is a joint World Bank/ DFID initiative focusing on emerging issues in the transport sector. Its goal is to generate knowledge in high priority areas of the transport sector and to disseminate to practitioners and decision-makers in developing countries.

CONTENTS

CONTENTS	III
ACKNOWLEDGEMENTS	V
ABSTRACT	VI
1 INTRODUCTION	1
2 TIME-BUDGET THEORY	3
3 INDUCED TRAVEL DEMAND	5
4 TRAVEL-TIME SAVINGS	8
4.1 CONCEPTUAL CHALLENGES.....	8
4.2 MEASUREMENT ISSUES.....	11
5 TRANSPORTATION PROJECT APPRAISALS OF THE WORLD BANK ..	14
6 EQUITY CONSIDERATIONS	15
7 ALTERNATIVE MEASURES	16
7.1 ACCESSIBILITY METRICS.....	16
7.2 MONETIZING ACCESSIBILITY BENEFITS	23
7.3 ECONOMIC DEVELOPMENT IMPACTS.....	26
7.4 COST-EFFECTIVENESS MEASURES.....	27
8 CONCLUSION	28
9 NEXT STEPS	30
REFERENCES	32

LIST OF TABLES

Table 1: Comparative Job Accessibility of Auto-Highway Versus Transit for Residents of San Diego’s Mission Valley, 2000	21
Table 2: Single-Family Housing: Hedonic Price Model for	24

LIST OF FIGURES

Figure 1: Tracing Induced Travel Demand.....	6
Figure 2: Comparison of how far one can travel by car versus public transport within 45 and 90 minutes in evening peak, London and São Paulo. Isochronic measures are imputed	19
Figure 3: Isochronic Measure of Job Accessibility in San Diego County via the Auto-Highway Network for a Mission Valley Census Tract, 2000. Source: Cervero (2005)	20
Figure 4: Isochronic Measure of Job Accessibility in San Diego County via the Public Transit Routes for a Mission Valley Census Tract, 2000. Source: Cervero (2005)	21
Figure 5: Marginal Effects of Walking Access to BRT Bus Stops on Commercial Land Values in Seoul over Distance Intervals. Source: Cervero and Kang (2011)	25

ACKNOWLEDGEMENTS

The “Going Beyond Travel-Time Savings: An Expanded Framework for Evaluating Urban Transport Projects” has been prepared for the World Bank Transport Anchor group (TWITR) in Washington which administers and manages the Transport Research Support Program, TRSP, a financing of **DFID**, the Department for International Development of the United Kingdom Government.

We would like to express our thanks to Robert Cervero, Department of City and Regional Planning, University of California, Berkeley, who was contracted to provide the framework and the technical content. Roger Gorham, Economist, AFTTR, provided guidance and advice throughout the preparation of the study.

ABSTRACT

This paper challenges the widespread and often indiscriminant use of travel-time savings as a principal metric of economic benefits for evaluating urban transport projects. Time-budget theory and empirical evidence reveals that the benefits of a widened road or extended rail line often get expressed by more and longer trips to larger numbers of destinations and not by less time spent traveling. Induced travel demand can also erode time-savings benefits over the long term. Other conceptual and measurement issues related to travel-time reductions as a welfare measure are raised as well. A case is then made for elevating accessibility improvements as an outcome measure, particularly in light of the long-term nature of urban transport investments. Examples of measuring and monetizing accessibility are provided, although applying these techniques in developing countries is never easy. Still, tractability of measurement is no reason for relying on measures like reduced travel time when doing so flies in the face of theory, logic, and empirical evidence. The paper concludes that the World Bank should adopt a more robust and inclusionary framework for evaluating urban transport projects, one that supplements mobility-based measures like travel-time savings with metrics tied to accessibility, sustainability, livability, safety, and affordability. A preliminary plan of action is proposed in this regard.

1 INTRODUCTION

Travel-time savings are the principal economic benefit assigned to urban transport projects. Other benefits, like reduced vehicle operating costs (e.g., less wear-and-tear on vehicles; improved fuel economy) and accidents, are sometimes monetized as well. Because they are difficult to measure, less tangible second-order impacts, like improved air quality, are often treated subjectively in economic evaluations. According to Mackie et al. (2001), travel-time savings capture 80% of the quantified benefits for transportation Cost-Benefit Analyses (CBA) in the United Kingdom. In a recent evaluation of proposed bus-way improvements in Lima, Peru, travel-time savings represented 75% of the project's total estimated benefits (World Bank, Latin American and the Caribbean Region, 2003). World Bank studies likewise use travel-time savings as the chief measure of economic benefits — e.g., as an overall indicator in Monitoring and Evaluation (M&E) frameworks and Bank-sponsored CBAs.

This paper questions the focus on travel-time savings as the core and sometimes even exclusive metric of user benefits. History shows that major improvements to roads and public transit do not reduce the amount of time per day urbanites devote to getting around a city. More often, they increase the number and length of trips.

Despite dramatic gains in the average speed of travel conferred by modern technology over the past century — faster cars, super-highways, limited-access/grade-separated freeways — the amount of time urbanites spend traveling has remained largely unchanged over many decades, if not centuries. As transport systems become speedier and cheaper, urban dwellers take advantage of these improvements by traveling more and over greater distances as opposed to saving time or money. If conditions allow, users prefer to broaden their range of options rather than reduce general costs of travel. Thus, the benefit of a new road or bus-way gets expressed more in terms of expansion of trade-sheds, labor-sheds, market-sheds, and social networks than spending less on physical movement. Stated another way, the chief benefit is increased “accessibility” — i.e., the ability to get to destinations and activities people want to reach — not less total time traveling. It follows that any assessment of prospective transport investment projects should give at least as much attention to estimated impacts on accessibility as to travel-time savings.

Accessibility is a function of two main elements: (1) mobility — speed between point A and point B; and (2) location — distance between points A and B. In the near term, faster speeds either save time or allow more interactions between a fixed set of origins/destinations, possibly over a larger geographic catchment. Over the longer term, they allow origins and destinations to be

farther apart – which, when unplanned, equates to sprawl but when well-planned can increase opportunities for job searching, trading, and social interaction.

Metz (2008) has been particularly critical about the conventional practice of equating benefits to shrinking travel times. He asserts: “travel time savings has the quality of a myth — a traditional story accepted as factual” (Metz , 2008, p. 333). Travel time savings, Metz argues, are transient. In the short term, the prospect of travel time savings can influence when, along which corridor, and by which mode one travels. But once the new route becomes part of an established pattern of daily activity, the benefit should be viewed as an improvement in access rather than as a savings in travel time.

2 TIME-BUDGET THEORY

Arguments for focusing on enhanced accessibility vis-à-vis travel-time savings are rooted in time-budget theory (Zahavi and Talvitie, 1980, Tanner, 1981). Despite rapid increases in average travel speed, people continue to invest roughly the same amount of time to move about a city, on average an hour per day. This daily time budget has held remarkably constant over time, from ancient Rome to the walking cities of 15th century Europe to the streetcar suburbs of the early 20th century and freeway-laced cities of today. Time budgets are seemingly an anthropological constant, as if people are genetically pre-disposed to spend a fixed amount of time during their lives moving about cities and their surroundings. If a new road speeds up this movement, people simply move more often or farther. Traveling longer means the boundaries of cities have stretched outward as average speeds have increased.

Scholars have long cited transportation systems and technology as powerful forces that shape cityscapes and economic growth patterns (Warner, 1962; Wachs and Crawford, 1992; Garrison and Levinson, 2006). One can easily trace the outward expansion of cities to a succession of transportation advances that increased average travel speeds. The maximum size of walking cities was around 20 square kilometers, which supported settlements up to 50,000 or so inhabitants. When electric streetcars gained ascendancy in the late 1800s, many cities quadrupled in size and with the advent of freeways the population and spatial extent of cities grew by several additional orders of magnitude (Schaeffer and Sclar, 1980; Muller, 2004).¹ Faster mobility has thus mainly changed the spatial organization of cities, not the amount of time devoted to travel.

Among the most persuasive evidence in support of time-budget theory is the following:

- In a study of world cities, Zahavi and Talvitie (1980) found a fairly constant amount of time and budget devoted to urban mobility — on average, around one hour per day moving about the city and around 11% of disposable income, with mean statistics three to four times larger than standard deviations.
- Zahavi (1979) also studied changes in travel patterns in the U.S. from 1958 to 1970, finding that Americans did not spend any less time traveling during a period when massive freeway construction let them travel considerably faster. A later study updated Zahavi's analysis

¹ A walking speed of 5 km/hour permits a 2.5 km return journey to be covered in one hour, producing a 20 km² range (a circle with a 2.5 mile radius). With car travel ten times faster, the access area becomes one-hundred-fold larger — i.e., 2000 km² (Lefevre, 2010).

using data through 1990, showing the earlier results still held (Barnes and Davis, 2001).

- Several other studies documented constancy in the amount of time, around 1.1 hours per day, that Americans invest in traveling (Ryan and Spear, 1978). McLynn and Spielberg (1978) found the one-hour-per-day figure held as early as 1840, a time when the first high-speed form of mechanized movement, steam-engine trains, spurred the industrial revolution and ushered in an era of decentralized growth in America.
- National surveys in the UK show that travel hours per person per year remained constant from 1970 to 2005 (around 350-380 hours), a period of massive motorway construction throughout the British Isles. According to Metz (2008), this implies “a long run value of travel time savings of zero”. What is preferred is more and longer trips – average distance travelled shot up by 60% over the 1970-2005 period.

3 INDUCED TRAVEL DEMAND

Time-budget theory holds that supply-side improvements increase speeds which alter cities and travel distances. A related theory, called induced travel demand, contends supply-side improvements alter cities and travel so as to erode speed benefits. The two are flip sides of the same coin.

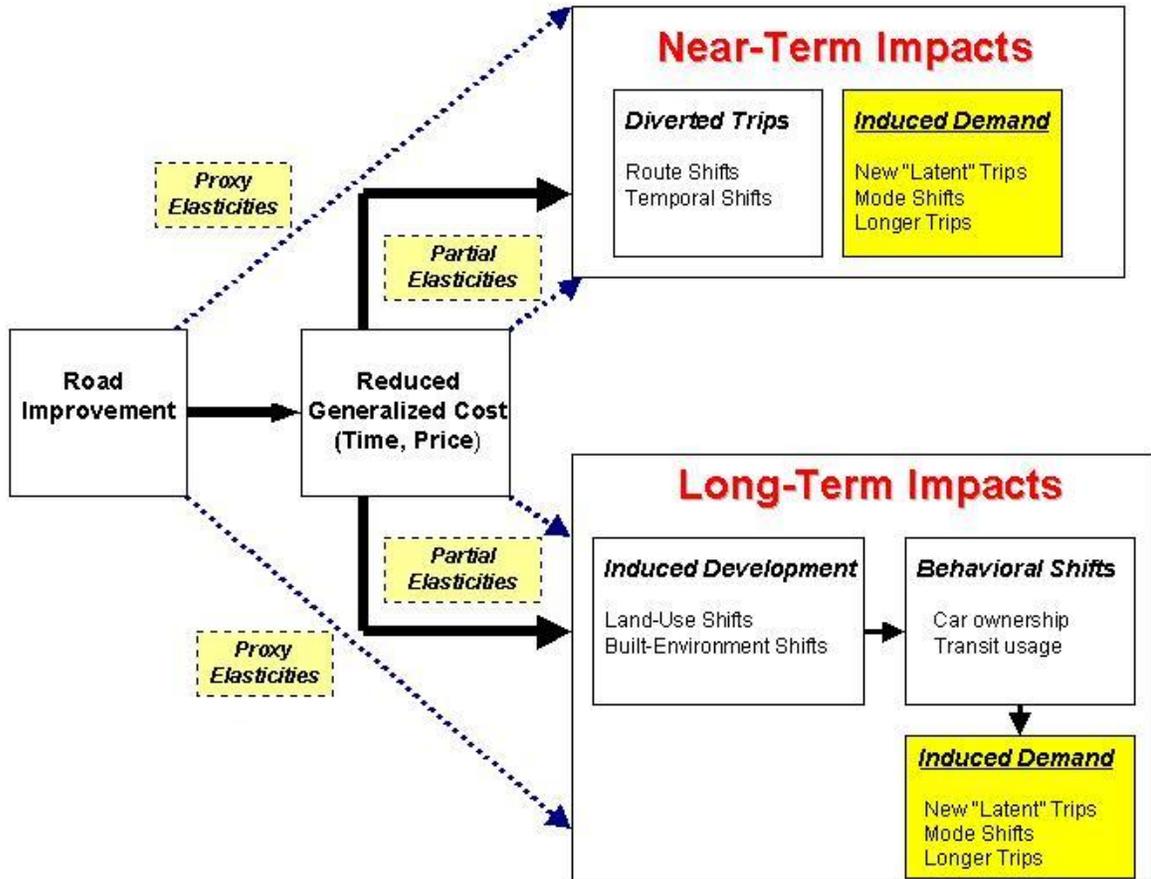
Critics of supply-side solutions to traffic congestion charge that the capacity-expanding benefits of most transport projects are short-lived. While all forms of transport investment influence travel, most complaints about the ephemeral benefits of added capacity are directed at the road sector. Figure 1 diagrams the flow of events attributed to the demand-inducing impacts of an expanded road. In the near term, increased capacity unleashes behavioral adjustments — e.g., trips previously suppressed are now made because of improved flows (i.e., latent demand); motorists switch routes, modes, or time-of-travel to take advantage of a new facility; motorists travel to destinations that are further away because of speedier flows (Downs, 1962, 1992; Cervero 2002; Noland and Lem, 2002). New trips, longer trips, and modal shifts contribute to increased Vehicle Kilometers Traveled (VKT), the strongest correlate to overall resource consumption and tailpipe emissions in the transport sector. Other adjustments, like route and temporal shifts, do not noticeably increase VKT and thus are largely redistributive in nature.

A meta-analysis found a mean short-term elasticity (between lane-km capacity and VKT) of several dozen roadway investments in the United States of 0.40 — i.e., all else equal, a doubling of road capacity was associated with a 40 percent increase in VKT within 1-3 years of the investment (Cervero, 2002). Over the long term, added road capacity led to more deeply rooted structural shifts, like increased car-ownership rates and more auto-oriented land-development patterns. Adding structural impacts to accumulated short-term ones markedly increases long-term elasticities — on average, 0.75 in the U.S. (Cervero, 2002). Other studies have estimated even higher long-term elasticities (Heanue, 1997; Fulton et al., 2000; Metz, 2008). Most empirical studies of induced travel demand have been conducted in the U.S. Metz (2008) has examined aggregate data to study nationwide trends in the UK. He found that average vehicle trip rates per household have changed little over the long run. This implies that induced traffic in the aggregate does not arise from increased journey frequency, retiming, or making entirely new additional journeys. Rather, Metz contends that induced traffic is generally the consequence of the choice of more distance destinations for the same journey purposes and is associated with changed land-use patterns. Metz also notes that induced traffic increases traffic accidents and vehicle emissions since they increase in lock-step with trip distances. Such factors should be adjusted in any long-range road project appraisal.

Overall, experiences reveal that travel adjusts to form a new equilibrium of traffic congestion following road improvements. This traffic-inducing and thus benefit-offsetting impact is incompletely accounted for by most economic appraisals of transport-facility investments (Downs, 1992; Saloman and Mokhtarian, 1997; Cervero, 2002; Cervero and Hansen, 2002; Ory et al., 2004).

This is true in developing and developed countries alike.² Ignoring induced-demand impacts further calls into question the validity of relying on reduced travel times as the standard bearer for gauging the benefits of capital investments in roads and transit facilities.

FIGURE 1: TRACING INDUCED TRAVEL DEMAND



The diagram shows near-term (i.e., first-order) and longer-term (i.e., second-order) impacts of expanded capacity. Initially, a road investment increases travel speeds and reduces travel times (and sometimes yields other benefits like less stressful driving conditions, on-time arrival, etc.); increased utility, or a lowering of “generalized cost”, in turn stimulates travel, made up of multiple components, including new motorized trips (e.g., latent demand, previously suppressed), redistributions (modal, route, and time-of-day shifts), and over the longer term, more deeply rooted structural shifts like land-use adjustments

² There are rarely, if ever, adjustments for induced demand in travel forecasts of proposed urban transport projects in developing countries. Typically the subject matter is not even raised. Only a few World Bank appraisals of urban transport projects conducted over the past decade, such as in Hanoi and Lima, acknowledged that generated traffic or induced demand was not considered in estimating of travel-time savings.

and increased vehicle ownership rates (that in turn increase trip lengths and VKT). Some of the added trips are new, or induced, and some are diverted.

It is likely the case that the phenomenon of induced demand is more pronounced in the developing world than in most advanced first-world economies. Traffic gridlock creates a huge pent-up demand for mobility. Highly congested, poorly planned cities can thus expect to see the inducement of many newly generated trips following a roadway upgrade.³ Over the long run, most new development in rapidly modernizing cities will gravitate to less-congested and newly expanded corridors, which are often on the urban fringes. In the Jakarta's, Nairobi's, and São Paulo's of the world — rapidly growing, bigger, denser, and poorer than their first-world counterparts — the transportation/land-use connection is robust, as are traveler responses to changes in road capacity and public-transport services.

³ This is partly due to the archaic designs of central cities in many developing countries, often laid out to accommodate foot and bicycle traffic. The ability to retrofit urban cores with new transportation infrastructure is constrained in most instances and the costs of road construction thus tends to be quite high. Asian cities, for example, have 12% to 14% of land dedicated to roads compared to 25%-40% in US cities (Gwilliam, 2003).

4 TRAVEL-TIME SAVINGS

This section discusses both conceptual and measurement challenges in operationalizing travel-time savings as a metric of economic benefits.

4.1 CONCEPTUAL CHALLENGES

Travel-time savings has been the centerpiece of transport economic analyses for approaching a half century (Small, 1992; Metz, 2008). Its popularity is as much due to the ease and convenience of measurement as to any theoretically grounded notion of why and how welfare — and particularly the welfare of the urban poor — would or should be improved by a transport investment.

There is a well-established literature on how to compare the benefits and costs of transportation proposals. Given the difficulty in determining how much consumers are willing to pay for, say, a new road, a common approach for imputing benefits is to multiply the predicted time savings to users by assumed values of time and sum the results (Mohring, 1961; Small, 1999; Banister and Berechman, 2000).⁴ This has become conventional practice since total economic benefits are fairly easy to derive by comparing estimated total Vehicle Hours Traveled (VHT) “with” versus “without” a proposed improvement. Assumptions are needed, such as the estimated value of time, however even these often go unchallenged — e.g., 40% to 50% of a city’s prevailing wage rate is what is typically assumed.⁵ In developing countries, where current and reliable travel data are often in short supply and calibrated models are sometimes borrowed from elsewhere, potential errors from applying standardized and simplified approaches are likely magnified. In using computer-generated estimates of travel-time savings to gauge benefits, one must ask whether ease of measurement has usurped theory and logic?

Among the conceptual challenges faced in examining economic benefits and travel-time savings are the following:

- *Time Frame.* There can be a disconnect between the 40-50 year service life of most transport infrastructure and the near-term time horizon in which benefits are measured (given fixed land uses and thus fixed origin-destination patterns). CBA evaluates long-lived transport infrastructure based mainly on estimates of short-term

⁴ Travel-time impacts of a specific road project are typically gauged throughout an entire network using the traditional four-step travel-demand modeling approach. This reflects the fact that the impacts of improving any single link reverberate throughout a network, affecting speeds and performance on other links as well. Impacts are also registered across modes. Proposed transportation investments, by saving travel time, generally influence model outputs by changing mode choice and route assignments. In more advanced models, such as when there is a feedback loop between the traffic assignment and land-use allocation phases, they may also influence trip generation and distribution.

⁵ This practice applies to developed and developing countries as well as road and non-road projects. The Mumbai rail capacity upgrade study, for instance, similarly set the value of passenger time at 40% of average wage rate for users of different models (World Bank, South Asia Region, 2002).

travel-time savings. These near-term estimates might then be straight-line extrapolated to 50 years in the future without any adjustments in assumed future land-use (and thus origin-destination) patterns.

Over time, land markets shift as changes in accessibility patterns and housing filtration occurs, newly formed households trade off housing and transport costs to maximize utility, and a host of other dynamic forces are unleashed that reshape cities and travel. By the time that market effects of a transport investment have played out, it is never clear whether the per-capita amount of time spent traveling actually declines, particularly for the urban poor. As noted earlier, empirical evidence suggests it does not.

- *Scale of Analysis.* Benefits can vary widely by the geographic scale of analysis. At the corridor level, significant time savings might accrue among those traveling along a newly expanded 10-kilometer highway. However at a larger geographical scale (i.e., sub-regional “meso-scale” or regional “macro-scale”), more traffic might be induced by the addition of new and longer trips on existing roads, thus slowing speeds. The net impacts might be no changes in travel time for the sub-region or metropolitan area as a whole. While temporal changes might be most dramatic at a small geographic scale like a corridor, within an entire travel-shed or at the regional level – the scale most appropriate for drawing welfare judgments on public-policy interventions – spatial changes are likely to be most dramatic, especially over the long run (which, of course, is the time frame most appropriate for evaluating projects).
- *Travel Trade-offs.* Urban economic theory suggests that travel time alone is not a sufficient indicator of welfare because it is “traded off” against housing values (i.e. site rents) (Alonso, 1964; Muth, 1969). Dictated by consumer preferences and often stage-of-lifecycle, some households willfully endure long commutes in return for lower-cost housing on a per-square meter basis. Stereotypically these are younger families seeking larger living spaces (and in the U.S., often better schools). Also stereotypically, once the kids have gone off to college, some “empty-nesters” downsize by moving closer to the city, effectively trading off less time spent traveling for higher priced housing per square meter. Measuring changes in travel time alone thus ignores the reality that transportation and housing are a bundled good in the minds of many households. Thus a new freeway or rail line might induce some households to move farther out and thereby increase total time spent traveling in return for cheaper housing — a utility-maximizing choice made within the limits of a fixed transportation/housing cost budget. In such instances, studying impacts on travel times alone becomes meaningless.
- *Path Dependence and Infrastructure.* Once a dominant technology, like the auto-highway combination, gains ascendancy, other modes can be marginalized as functional carriers, to the long-term detriment of a region at large. Mogridge (1997) argues that investing exclusively

in road transport at the expense of other alternatives may cause a lower net welfare and higher congestion than a modally diverse investment strategy. He contends that roadway capacity expansion and similar congestion-mitigation policies actually increase travel times in the long-term in many urban settings. Building on theories of induced travel, Mogridge asserts that the modal convergence of switching from transit to auto travel in response to congestion-mitigation policies ultimately leads to deteriorating transit service, auto dependence, gross increases in travel time, and even more congestion. Perhaps car-dependent U.S. metropolises like greater Los Angeles and Houston provide the strongest empirical backing of this viewpoint. Despite averaging high levels of freeway capacity per capita, Los Angeles and Houston have over the past two decades consistently ranked as among the most congested areas in the country in terms of annual hours of delays per traveler (Schrank et al., 2010).

The obverse of this path dependency argument can be seen when tracing the impacts of pursuing a more balanced, multi-modal transportation program. In the case of Seoul, South Korea, for example, road capacity has been reduced in the core area (e.g., the Chenggyecheon freeway-to-greenway conversion; replacement of a large traffic circle in front of City Hall by an oval civic green), replaced by expanded Bus Rapid Transit (BRT) and other transit service reforms. Commercial and residential land prices increased following these road-to-amenity conversions (Kang and Cervero, 2009; Cervero, 2010; Cervero and Kang, 2011). In Seoul's case, property markets placed a higher premium on neighborhood quality, livability, and public amenities than mobility or swiftness of movement. Seoul's experience also demonstrate that the withdrawal of road capacity matched by stepped-up public-transport services can yield net welfare benefits.

- *Time Loss = Reduced Productivity?* Arguments that congestion-induced travel delay results in lost productivity are questionable, at least as a *carte blanche* assumption (Stopher 2004). While current research on traffic congestion attributes substantial economic drags to time losses or scheduling delays, it does not offer any guidance on whether these delays constitute foregone productivity. Transportation infrastructure is not productive in and of itself; rather the service and accessibility premiums it provides enable agglomeration economies or transport savings that function as direct inputs into productivity (Boarnet 1997). Although congested conditions may appear to be less productive than higher speed, non-peak conditions, many users clearly derive benefits from traveling during specific times (such as peak commuting hours) and to specific locations, despite the lower travel speeds. If an employee finds that his or her commute is 15 minutes longer due to congestion, he or she may leave for work earlier or may depart from work later in order to make up the additional work time. Also, 15 minutes of congestion delay would not replace economically productive time for an individual traveling to a social event after shopping. While foregone recreational time would certainly be valuable from a cost-benefit

analysis perspective, it is not economically productive (at least in the traditional sense of the word). Even for commuters, 15 minutes of delay might simply replace 15 minutes of idle time that would have been spent sometime during the workday or after work. Downs (1992; 2004) argues that time stuck in traffic is not necessarily stressful for some. Rather it might be the one time of the day when office workers enjoy solitude and quiet, comforted by the posh interior of a car playing relaxing music or having a novel recited on a high-end stereo unit. For some, sitting in an office bullpen separated by thin partitions from co-workers chatting on the phone might be just as stressful or unproductive.

4.2 MEASUREMENT ISSUES

Besides conceptual challenges, economic appraisals based on travel-time metrics face a number of practical measurement-related problems as well. These are discussed below.

- *Travel Surveys.* Data on travel times are usually obtained from self-reported travel diaries of a random sample of households in a region. This poses numerous problems, especially in cities of the developing world. One, informality and incomplete land registries make defining a population base from which to sample households virtually impossible. Since the poor most likely live in informal or itinerant settlements, they are most likely to be under-sampled. The same holds for any data-collection instrument using random-digit dialing of telephone numbers since the poor are least likely to have a landline or cell phone. Two, travel-diaries presume literacy and because they are self-reported, are easily subjected to biased or incorrect responses. Such issues are again most likely to surface for low-income individuals and households. However biases can also be introduced by failing to compile data from the wealthiest members of society. A travel-diary survey of households in Bogotá, Colombia, for instance, recorded low response rates from not only the two lowest income strata but also the highest (Cervero et al., 2009).⁶ In a city once known as the “kidnap capital of the world” and where narco-terrorist attacks still occur, most wealthy households have armed guards whose sheer presence deter surveyors from approaching their properties. Lastly, household surveys fail to capture non-home-based or non-household travel, such as by commercial trucks, taxis, paratransit/informal-transport, or inter-city through traffic.
- *Derived estimates.* Sometimes travel-time impacts are not estimated directly but rather derived from estimated future travel speeds and invoking the questionable assumption that trip origins and destinations will be unaffected by changes in transport system

⁶ Under-sampling of the lowest income stratum was due to households living in squatter settlements and either being unavailable or unable to comprehend the purpose of surveys. Illiteracy and cultural factors (e.g., unavailability of having someone of a higher income stratum enter a tattered shelter) accounted for low response rates among the next-to-lowest income stratum.

performance. This is common practice in the World Bank M&E framework. As already noted, smoother flowing traffic can unleash behavioral changes, such as the inducement of new trips or route shifts. Imputing travel times can also be problematic since trip durations often vary considerably from the statistical mean – e.g., by time-of-day, mode, section of corridor, etc. Imputing travel-time savings from average speeds is especially difficult in the developing world due to huge variations given the rather erratic and stochastic nature of traffic flows.

Computational errors are also possible when one invokes the simple assumption that changes in average speed and travel times are proportional. The current average speed is typically estimated by local traffic engineers using a floating car technique — i.e., a test car will pass as many vehicles that passes it over a defined distance, establishing a mean speed for a particular time-of-day. Say the recorded peak-period average speed for a hypothetical 10-km stretch of road is 40 kph. And assume a road improvement is expected to increase this figure to 50 kph. Ignoring issues of induced demand and induced growth effects, this is a 25 percent increase in mean speed. Does this mean average travel times similarly fell by 25 percent? Simple math shows this is incorrect (owing to different denominators used in measuring rates of change). It takes 15 minutes to cover the 10 km stretch at 40 kph and 12 minutes to do so at 50 kph. That's a 20 percent decline in mean travel time for a 25 percent increase in mean speed. Over a fixed distance, speed/travel-time trade-offs are not strictly proportional.

- *Absence of land-use adjustments.* The failure of the vast majority of travel-forecasting models to account for land-use adjustments poses a serious measurement problem in estimating travel-time benefits. The absence of any feedback loop from traffic assignment to land-use allocations implicitly assumes that trip origins and destinations do not change over time. As a result, Metz (2008) argues that the value of activities at trip ends “could be disregarded” since they are the same between the “do nothing” and “do something” alternatives. While travel demand might vary as a result of new infrastructure (as captured in trip distribution, modal split, and traffic assignment phases), the change in trip origins and destinations themselves (in the land-use allocation phase) is usually ignored. Thus, possible economic benefits of land-use adjustments — e.g., better matching of firms and labor; agglomeration economies from more efficient, clustered spatial arrangements; increased comparative shopping — get overlooked. Implicitly, this absence presumes no economic benefits are conferred by land-use adjustments. Assuming trip origins and destinations will not change following any transport-infrastructure enhancement flies in the face of theory, logic, and empirical evidence.
- *Valuations.* Time valuation stems from cost-benefit analysis (CBA) methods which compare the relative merits of two or more transportation alternatives. While researchers agree that the value of

time is related to the regional wage rate (Small 1992, Miller 1989), they do not agree on how to determine its present value. Many cite half of the wage rate, however the range extends from virtually nothing to values greater than the wage rate (Rouwendal and Nijkamp 2004).⁷ Some analyses apply specific values of time to different socio-economic groups, trip purposes, or times of day, while others use average estimates.⁸ Some research indicates that different trip lengths and savings increments are valued differently. There is likely an indifference zone wherein small time savings are imperceptible. Few people will notice a minute or two savings on a half-hour trip however 10 minutes of savings on a 30-minute trip will be impressionable. Due to the induced-demand/induced-growth phenomenon, most supply-side expansions are likely to shave a few minutes of travel time versus big perceptible savings.

Measuring value-of-time is more complicated for non-highway infrastructure. This is partly due to the predominance of road infrastructure in cities. Rarely will an investment in pedestrian infrastructure increase speeds and thus save time. New bike lanes might divert riders from faster direct routes and thereby increase travel times. For transit users, service reliability, transfer-free direct connections, and perceived levels of safety may be more heavily valued than time (Train, 2009). For such reasons, reliance on travel-time savings as the core metric of economic benefits of urban transport projects engenders a road-based bias.

⁷ Small (1992) estimates that the value of time for trips range between 20% and 100% of a region's prevailing wage rate and estimates that 50% is a good rule of thumb for peak-hour users. Parry et al. (2007) give a rough estimate of total transportation costs per automobile mile in the U.S. — \$0.05 attribute to congestion.

⁸ A project appraisal of rail capacity upgrading, for example, set the value of time of high-income railway users at 2 ½ times higher than low-income ones (US\$2.40 versus US\$0.99 per hour) and those with formal jobs were assumed to value time twice as much as those with informal ones (US\$2.73 versus US\$1.30 per hour) (World Bank, South Asia Region, 2002). An appraisal of a bus-way proposal in Lima used a value of time of US\$0.80 per hour for those traveling by private vehicles and US\$0.31 for public transport riders (World Bank, Latin America and the Caribbean Region, 2003).

5 TRANSPORTATION PROJECT APPRAISALS OF THE WORLD BANK

Many of the issues discussed in the preceding sections apply to project appraisals conducted as part of loan packages for World Bank-funded projects. The economic appraisals of seven World Bank studies were examined in terms of their approach to measuring economic benefits.⁹ Most rely on travel models to estimate differences (with versus without improvement) in network-wide VHT (reflecting total system-wide travel-time expenditures). Some address other impacts, like reductions in accidents and air pollution, as a consequence of changes in both VHT and VKT. Benefits from reduced VHT and VKT are compared to estimated costs to come up with net present value (NPV) and Benefit/Cost ratios.

Few appraisals dealt with induced demand or any generated-traffic impacts that could erode travel time benefits over time. Most appraisals did not even acknowledge the possibility of induced-demand/induced-growth impacts. To the degree they are even used, it is not clear that travel-demand forecasting models contain feedback loops between traffic assignment and earlier input stages (including initial land-use allocations). Models appear to gauge near-term travel-time savings and assume these will remain fixed and unchanged over the life of a project, annualizing these values and extrapolating them over a set number of years — and in so doing, failing to account for land-use and behavioral adjustments. Travel-demand models do not appear to have been estimated in some of the poorest cities of the world, thus how travel-time savings are derived in these settings is unclear.

⁹ Report sections on “economic evaluations” were examined for project appraisals of proposed loans and grants for urban transport projects in Ghana, Hanoi, Lagos, Lima, Mumbai, Rio de Janeiro, and Urumqi.

6 EQUITY CONSIDERATIONS

Reliance on travel-time metrics also raise equity concerns. Travel-time savings accrue mainly to motorists, yet many poor in the developing world — where most World Bank urban transport projects are targeted — do not own a car or drive. Their values of time might also be substantially less than those of the middle and professional classes. For them, enhanced access opportunities might be a bigger benefit — and contribute to the World Bank’s over-arching objective of poverty alleviation — than reduced travel-time expenditures. The ability to widen the territorial sphere for job searching, saving on food purchases, reaching medical clinics, and seeking educational opportunities is likely to benefit the poor more than saving a few minutes of time moving along an expanded roadway.

Experiences also show that the poor are willing to trade-off travel-time delays for lower transit fares, parking rates, or fuel prices — i.e., they tend to be more price-sensitive and less time-sensitive than the non-poor. More popular uprisings have been sparked by increases in fuel prices and bus fares than by delays in travel times. For such reasons, the use of travel-time savings as a singular metric of benefits is all the more questionable from an equity point-of-view.

7 ALTERNATIVE MEASURES

The critiques of reliance on travel-time savings to gauge economic benefits does not mean they should be discarded. Rather they are just one of a number of measures that should be examined when weighing economic benefits of highway, public transport, and other transport infrastructure investments. A more complete palette of metrics for gauging benefits – one that includes changes in accessibility across a multitude of purposes – should be considered.

7.1 ACCESSIBILITY METRICS

So far, this paper has made the argument that one of the major benefits of expanding roadway capacity and transport services is to enhance access to places where travelers want to go. Access is a theoretical construct as opposed to a manifest behavior, and for this reason can be difficult to grasp. Access is about opportunities versus revealed choices and outcomes.

Besides more directly capturing the benefits conferred by transport investments, the inclusion of accessibility measures promotes a more balanced approach to long-range urban planning. Notably, it gives attention to alternatives to capital investments strategies for reducing traffic congestion and mitigating environmental problems, such as promoting efficient, resource-conserving land-use arrangements. This is because accessibility is a product of *mobility* and *proximity*, enhanced by either increasing the speed of getting between point A and point B (mobility), or by bringing points A and B closer together (proximity), or some combination thereof. Since accessibility is a product of both travel time and the geographic location of urban activities, it captures not only the temporal but also spatial dimension of travel. Thus accessibility measures give legitimacy to land-use initiatives and urban management tools in addition to supply-side, mobility-enhancing measures. Focusing on accessibility improvements as a goal reflects the “derived” nature of travel demand and puts the focus on promoting interaction — e.g., trade, social contacts, engagement with nature – versus movement per se. Some would argue most people want to minimize the time traveling so that more time can be spent at the destination. Framing the objective as making cities more accessible versus more mobile prompts a paradigmatic shift in planning, elevating land-use management and information technologies as bona fide tools for managing traffic flows and mitigating traffic congestion.

Measuring Accessibility

While there is a conceptual elegance to gauging benefits in terms of changes in accessibility, operationalizing this is not easy. For this reason, accessibility is typically handled qualitatively. The appraisal of a proposed BRT investment in Lagos, for example, offered a simple qualitative statement in support of the project on social grounds, noting “the proposed project would benefit women, the elderly, and the physically challenged by responding to their needs and providing them with *better access* to basic social services (health, school, administration), jobs, and markets, at a lower cost than currently available” (World Bank, Africa Regional Office, 2009, p. 26).

There are quantitative ways to gauge changes in accessibility. Going from concept to measurement involves mathematics and, increasingly, the power of Geographic Information Systems (GIS) tools. Two approaches are commonly used: (1) gravity-like measures (based on the denominator, or balancing factor, of a singly-constrained trip distribution model); and (2) isochronic measures (indicating the cumulative count of opportunities reachable within a given travel time or distance).¹⁰

Accessibility is normally measured for specific purposes – such as accessibility to jobs, hospital facilities, retail outlets, etc. In the case of job access, the two approaches to capturing access can be expressed as:

Gravity-based Index:

$$AI_i = \sum_j [Jobs_j * F_{ij}] \text{ where: } F_{ij} = \exp(-v \text{ Time}_{ij}) \text{ or } F_{ij} = \text{Time}_{ij}^{-v} \quad (1)$$

AI	=	Accessibility Index
Jobs	=	# of jobs in tract
Time	=	network travel times
I	=	residential zone
J	=	employment zone
v	=	estimated impedance coefficient

Isochronic-based Index:

$$AI_i = \sum_j [Jobs_j (\text{Time}_{ij} \leq m)] \text{ where, in addition to above:} \quad (2)$$

M	=	time threshold (e.g., 30 minutes)
---	---	-----------------------------------

Gravity-like measures of accessibility consider all trip-end possibilities within a defined study area in weighing the drawing power of potential trip attractions, corrected for the friction of distance or time in reaching them. However the AI value of a gravity-based measure is often meaningless unless compared to another value — such as the AI of the poor and non-poor or of auto-highway versus public transit options. Regardless of how they are measured, the value of an accessibility index, like any performance indicator, lies in a comparative context. According to Handy and Niemeier (1997, p. 1181), “no one best approach to measuring accessibility exists; different situations and purposes demand different approaches.

Isochronic measures receive high marks for their transparency and intuitiveness (Koenig, 1980). Anyone can relate to a value such as the presence of 200 hospital and medical-clinic beds within a half-hour bus ride as

¹⁰ Other measures, like random utility and prism-based approaches, can be found in the literature, though these tend to be applied less often in practice, partly because of data limitations (Niishi and Kondo, 1992; Kitamura et al., 1998; Handy and Clifton, 2001).

a gauge of how accessible one is to medical care via transit. GIS allows isochronic measures to be visualized. Perhaps the biggest drawback of isochronic measures is they require the analyst to draw a time or geographic boundary for gauging access, which is sometimes arrived at subjectively.

Cross-City and Longitudinal Comparisons

As noted, accessibility metrics find most advantage when used as a comparative indicator, either between places or in a longitudinal context. Casiroli (2009) did a cross-city comparison of access to central tourist destinations in São Paulo (Praça de Sé) and London (Trafalgar Square) by mapping out how far one can get within 45 minutes (in green) and 90 minutes (in yellow) by car versus public transport in the evening peak (Figure 2). Summing the number of inhabitants residing within these travelsheds produces an isochronic measure of relative accessibility to these major leisure destinations by mode. Modal ratios reveals that more than twice as many Paulistas can reach Praça de Sé by private car than public transport in the P.M. peak. If reducing the carbon footprint of the transport sector and promoting more balanced transportation are long-range goals of São Paulo's transportation planners, then shrinking this differential over time would signal progress. A smaller ratio would also better reflect benefits accrued from improving metrorail and metrobus services than would an estimate of transit travel-time savings.

The accessibility profiles of competing transportation modes was recently studied over time in San Diego using isochronic metrics (Cervero, 2005). Figures 3 and 4 present comparative levels of job accessibility of those residing in the fast-growth Mission Valley area of San Diego via auto-highway and transit modes, respectively. Cumulative employment counts for 15-minute isochrones are also shown in each figure. The visual scan reveals that the near-ubiquitous road network in San Diego County covers a much larger geographic territory, and thus opens up greater access to jobs, than does the region's bus, light-rail, and commuter-rail systems. Not only are the isochrones in Figure 4 more geographically contained, they are also noncontiguous and spotty, indicating large gaps in transit service coverage.

FIGURE 2: COMPARISON OF HOW FAR ONE CAN TRAVEL BY CAR VERSUS PUBLIC TRANSPORT WITHIN 45 AND 90 MINUTES IN EVENING PEAK, LONDON AND SÃO PAULO. ISOCHRONIC MEASURES ARE IMPUTED

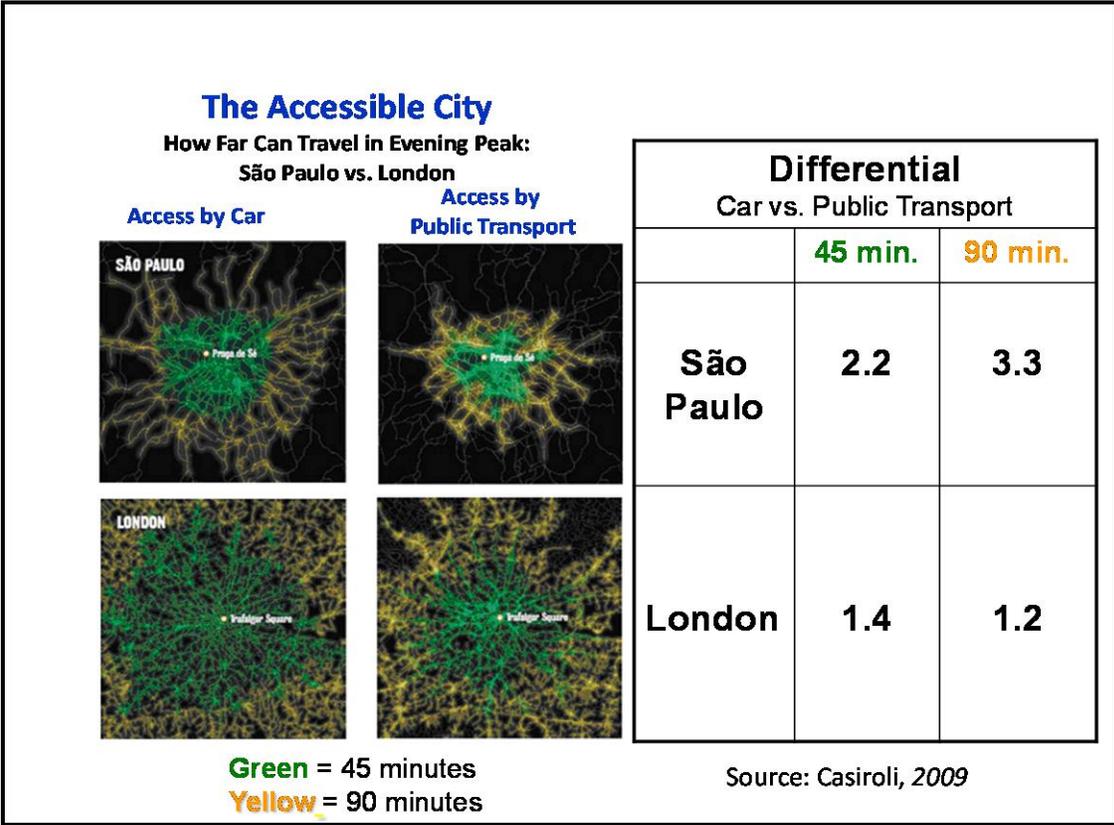


FIGURE 3: ISOCHRONIC MEASURE OF JOB ACCESSIBILITY IN SAN DIEGO COUNTY VIA THE AUTO-HIGHWAY NETWORK FOR A MISSION VALLEY CENSUS TRACT, 2000. SOURCE: CERVERO (2005)

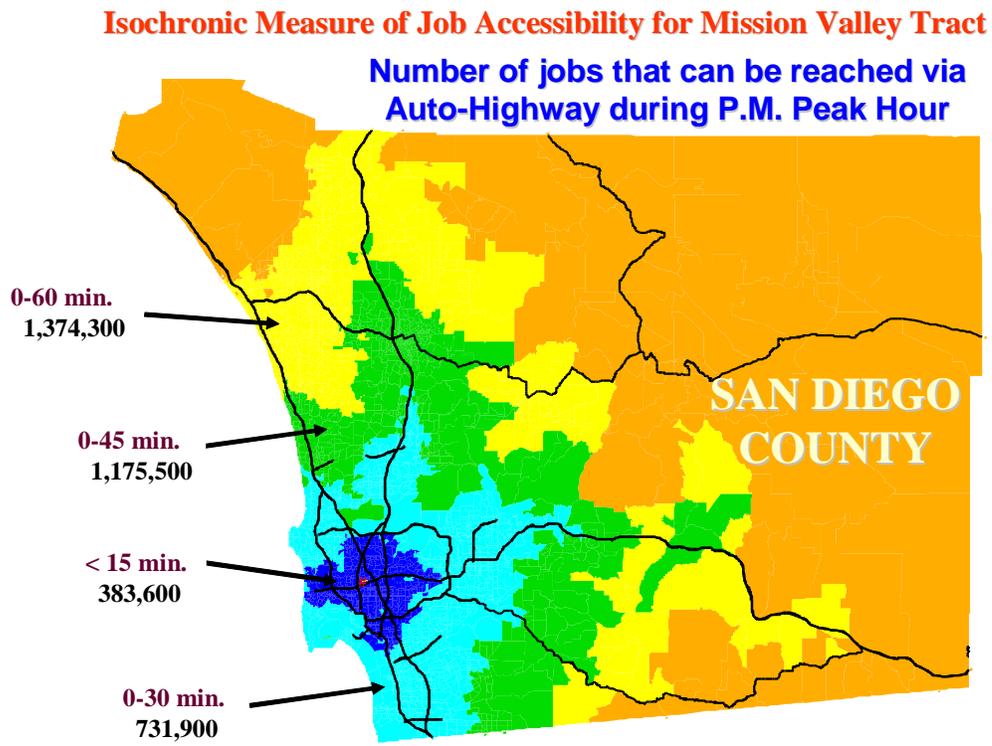


FIGURE 4: ISOCHRONIC MEASURE OF JOB ACCESSIBILITY IN SAN DIEGO COUNTY VIA THE PUBLIC TRANSIT ROUTES FOR A MISSION VALLEY CENSUS TRACT, 2000. SOURCE: CERVERO (2005)

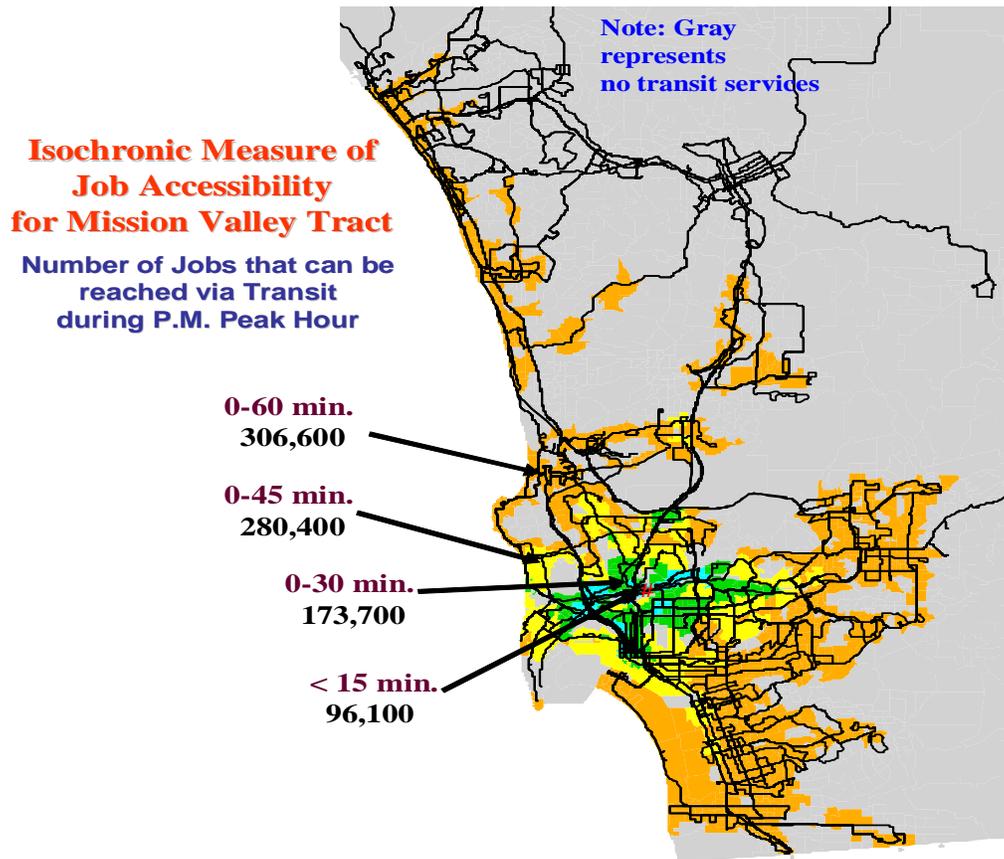


TABLE 1: COMPARATIVE JOB ACCESSIBILITY OF AUTO-HIGHWAY VERSUS TRANSIT FOR RESIDENTS OF SAN DIEGO'S MISSION VALLEY, 2000

Time Isochrone	A.I. Auto	A.I. Transit	Accessibility Advantage: Auto to Transit	MAG ¹
< 15 Min.	383,600	96,100	3.99	-.0559
15-30 Min.	731,900	173,700	4.21	-0.616
30-45 Min.	1,175,500	280,400	4.19	-0.614
45-60 Min.	1,374,300	306,600	4.48	-0.635

¹ MAG (Modal Accessibility Gap) = $(A^P - A^C)/(A^P + A^C)$, where A^P = AI of public transport and A^C = AI of private transport.

The comparative job accessibility advantages of auto-highway travel over public transit for residents of Mission Valley are shown in Table 1. Over all four travel-time rings, drivers enjoy a four-to-one accessibility advantage over transit riders. In general, the farther out one goes from the center, the job-

accessibility advantage enjoyed by motorists over transit users increases.¹¹ The comparative AI values were computed for 99 neighborhoods in San Diego in addition to the Mission Valley and averaged to derive a countywide comparative measure of job accessibility by mode. Also, smart-growth and business-as-usual plans for 2020 were compared not only in terms of conventional performance measures (like VKT and VHT) but also in terms of how they narrowed the accessibility disadvantages experienced by transit users. Transit-oriented growth could reduce the automobile's job-accessibility advantage by 60 percent in year 2020 compared to a business-as-usual scenario (Cervero, 2005).

In transit-oriented cities, the accessibility advantage enjoyed by motorists, such as in San Diego, would flip in favor of transit users. A recent study revealed that Hong Kong residents were far more accessible to jobs via the city's highly integrated network of public and private bus, metro-rail, tramway, ferry, and even funicular than via private car (Kwok and Yeh, 2004).¹²

Increasing Accessibility or Sprawl?

As discussed earlier, studies show that capital investments in roadways and transit lines appear to increase the number and length of trips more than reduce total travel times. Findings that people travel more and farther does not necessarily mean they do so by choice or derive utility in such behavior. Higher accessibility could reflect the impacts of sprawl — i.e., trip origins and destinations being farther apart, producing longer journeys, albeit at faster average speeds. Expanded travel-sheds can equate with increased benefits (e.g., productivity gains from better matching of firms' labor-input needs and workers' job preferences) but also high environmental and energy costs.¹³ Accordingly to Siegel (2010), the yearly distance the average American drives doubles every few decades — from 4,009 miles per capita in 1960 to 9761 in 2000. Does this mean that levels of access or even quality-of-life for Americans have similarly doubled? It is for reasons like this that accessibility metrics should to be supplemented by others — including changes in vehicle miles traveled (VMT) and travel durations — in evaluating transportation proposals.

¹¹ Table 1 probably understates the accessibility advantages of automobile travel because out-of-vehicle times in accessing and waiting for transit are generally understated in the zone-to-zone travel time estimates of transit.

¹² The computed MAG level (defined in the footnote of Table 1) for Hong Kong was 0.856 in 1996, down from 0.937, meaning the big accessibility edge enjoyed by public transport eroded some during the 1990s. Zero MAG values indicate equal accessibility among modes while values close to one (in absolute terms) denote extreme disparities.

¹³ Similar arguments can be made about expanded housing choices. Under the theory of choice, households search to find the right combination of public services and accessibility so as to maximize their utility. Those seeking to minimize commuting are likely to pay higher real-estate prices for job-accessible locations (Alonso, 1964; Muth, 1969). Thus expanded accessibility can mean expanded residential choice sets.

7.2 MONETIZING ACCESSIBILITY BENEFITS

While accessibility indicators are useful metrics for inter-modal comparisons and assessing likely impacts of transportation and land-use plans over time, they need to be expressed in monetary terms if they are to be of much use in economic appraisals. Consumers no doubt benefit from having more retail outlets to choose from. Employers similarly benefit from an enlarged laborshed from which to seek out new workers and fitness buffs benefit from having more recreational opportunities within a half hour of their residences. Assigning an economic value to such benefits, however, is challenging.

Willingness-to-Pay Approach

One approach to valuing access is to measure willingness-to-pay, applying stated preference techniques (Metz, 2008). Using various scenarios, residents might be asked how much they would be willing to pay for increased access to shopping choices. Or businesses might be asked about their willingness to pay for shaving an average of 5 minutes off the daily commute of their work forces. The willingness-to-pay approach, of course, relies on subjective responses to “what-if” scenarios. It presumes respondents have the capacities to carefully weigh and value options and to make informed choices, even if they have no first-hand experiences with those choices.

Land-Value Capitalization

The impacts of increased accessibility get expressed in land prices. There is a finite, limited supply of good, accessible locations in a city. In a reasonably well-functioning marketplace, those seeking accessible locations to open a shop or business will bid up the price for well-located, accessible properties. Land markets thus capitalize the benefits of accessibility.

To gauge capitalization benefits, hedonic price models are widely considered to be the best method available. Hedonic price theory holds that most consumer goods comprise a bundle of attributes and that the transaction price can be decomposed into the component (or ‘hedonic’) prices of each attribute (Rosen, 1974). Using estimation approaches like ordinary least-squares regression, hedonic price models apportion sales-transacted real-estate values among causal explainers, shedding light into the marginal contribution of factors like accessibility, land-use type, and neighborhood quality.¹⁴ For purposes of gauging land-value benefits, hedonic models generally take the form: $P_i = f(L, N, C)$, where P_i equals the estimated price (per square meter) of parcel i ; L is a vector of location and regional accessibility attributes (e.g., accessibility to jobs); N is a vector of neighborhood characteristics (e.g., presence of mixed land uses; median housing income); and C is a vector of

¹⁴ Many studies use data on rents as opposed to sales prices for real-estate transactions (that are open, arms-length transactions). Rental data can be problematic, however, in that contract rents do not always capture the full array of concessions received by tenants. Even if contract rents are fairly accurate, they need to be adjusted for occupancy levels to reveal effective contract rates. Data limitations often preclude this. Focusing on sales transaction data avoids such problems.

controls (e.g., fixed-effect variables).

Table 2 presents hedonic-price model findings on the impacts of accessibility on real-estate prices in San Diego (Cervero, 2004). This was part of a larger study on the capitalization effects of proximity to San Diego’s light-rail transit line. Only the output pertaining to the impacts of Accessibility Indexes on single-family home prices are shown in the table. The model, which explained 60 percent of variation in housing prices, shows that single-family homes fetched more than \$1,000 for every 1,000 additional jobs within 30-minutes peak travel time, all else being equal. Employment access via transit increased the value of single-family homes even more: for every 1,000 additional jobs within 15 minutes travel time by bus or rail, sales value rose by nearly \$6,300, holding other factors constant. Clearly, home-buyers in San Diego placed a high premium on job access by public and private modes of commuting, consistent with residential location theory.

TABLE 2: SINGLE-FAMILY HOUSING: HEDONIC PRICE MODEL FOR

<i>Variable</i>	Coefficient	Standard Error	Prob. Value
<i>Accessibility</i>			
Regional Job Accessibility, Highway: Number of jobs (in 1,000s, 1995) within 30 minute peak-period auto travel time on highway network	1,042.0	160.4	.000
Regional Job Accessibility, Transit: Number of jobs (in 1,000s, 1995) within 15 minute peak-period transit travel time on transit network	6,286.5	710.2	.000

Control variables in model: attributes of property (e.g., size, location); attributes of buildings (e.g., size, number of bedrooms); attributes of neighborhood (e.g., median household incomes; school scores); municipal fixed effects.

N = 14,576

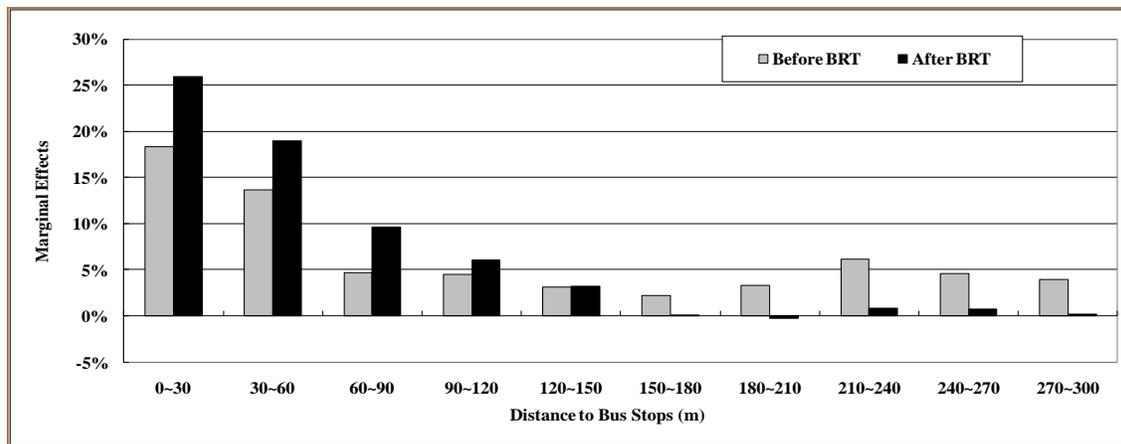
R² = .605

Source: Cervero (2004)

A more recent study of upgraded Bus Rapid Transit (BRT) services in Seoul, South Korea similarly relied on hedonic price modeling to assess impacts on both residential and commercial real-estate market performance (Cervero and Kang, 2011). The study focused on how changing from a modest BRT curbside-lane configuration to a more substantial dedicated center-lane operation got capitalized into retail-commercial land prices. Data were compiled for more than 37,000 commercial real-estate properties within an estimated impact zone of the BRT-upgrade project for two time periods: 2001-2004 (curbside operations) and 2005-2007 (center-lane operations). Multi-level modeling was used to estimate benefits of proximity, or access, to the BRT corridor before and after the upgrade. The coefficients on dummy variables that measured the shortest walking distance of commercial parcels to the nearest BRT indicated whether proximity affected land prices differently

before and after the BRT improvements. Figure 5 plots these coefficients, revealing the marginal effects of proximity on land prices, expressed in percentage terms and over 30 meter distance bands, relative to parcels more than 300 meters away (defined as the impact zone of the project). While access benefits accrued to those living near BRT corridors in both periods, the figure reveals the benefits were more prominently capitalized into land values in the post-period (2005-2007). Benefits were the greatest within 150 meters of the nearest BRT stop. A recent study of access to rail lines in Bangkok found similar results, with the premium of transit accessibility estimated to be \$10 for every meter that a property lies closer to a station (Chalermpong, 2007).

FIGURE 5: MARGINAL EFFECTS OF WALKING ACCESS TO BRT BUS STOPS ON COMMERCIAL LAND VALUES IN SEOUL OVER DISTANCE INTERVALS. SOURCE: CERVERO AND KANG (2011)



Hedonic modeling results such as those reviewed above express a monetary premium conferred by accessibility improvements. For purposes of estimating a total economic benefit, the per square-meter premium needs to be multiplied by the number of square meters within the estimated impact zone of a project.¹⁵ If, for example, the mean land-value premium of a transportation improvement is \$10 per square meter and this benefit extends over 100 hectares (or one million square meters), then the project's economic benefit could be set at \$10 million. Values might be adjusted to reflect changes in capitalization impacts over time (e.g., over the service-life of a capital project) or over space (e.g., reflecting the fact that premiums vary geographically, such as shown in Figure 5).

The presence of land-value premiums should not be added to the monetary value of travel-time savings. To do so would be to double-count since land values embody travel time savings. If consumer benefits are measured as a function of hours of travel saved multiplied by value of time per hour, changes in land values, which capitalize these benefits, should not be included as a benefit (Mohring, 1961; Small, 1999; Banister and Berechman, 2000). Thus,

¹⁵ For more on this method of estimating total economic benefits using hedonic-price model results, see Cambridge Systematics et al. (1998).

accessibility benefits should be treated as a supplement to travel-time metrics or an alternative perspective for gauging impacts, not an un-related add-on.¹⁶

Applying land-value capitalizations to measure accessibility might be problematic in many developing countries. The absence of well-functioning land markets in some poor countries could distort estimates. Informality, complex patterns of land tenure, and incomplete land registries pose further hurdles (Törhönen, 2004). One approach might be to estimate shadow land prices however doing so for a multitude of informal parcels within the impact zone of a transport project might be impracticable.¹⁷ Chalermpong (2007) states that very few hedonic studies have been published on the effect of transit accessibility on property values outside North America and Europe because data are often unreliable or non-existent. It could be that land markets in developing countries engender so many distortions and misallocations that reliably imputing accessibility benefits from land price data is nearly impossible. For these reasons, the use of accessibility indices as comparative and longitudinal measures — and as supplements to travel-time savings estimates — might be the best one can hope for in many developing country settings.

7.3 ECONOMIC DEVELOPMENT IMPACTS

The benefits of increased accessibility can also be expressed in terms of second-order effects on net economic growth in a region. This might be done using an input-output model that enumerates inter-industry production and linkages that occur as a consequence of, among other things, improved access to factor inputs (e.g., labor, raw materials) and markets. Economic forecasting and simulation models, such as REMI, can use accessibility along with other input metrics to predict changes in business output, sales, gross regional product, employment, and population over a specified time horizon.

Economic development impacts are typically treated as a second-order “add on” benefit of transportation projects in urban settings. In rural areas, however, they can very well be the chief economic benefit. In most rural parts of developing countries, traffic levels are too low for there to be any measurable benefit of a roadway investment using conventional consumer surplus measures. However the prospect of stimulating trade and increasing agricultural production might be substantial. A recent evaluation of a proposed road upgrade between northeast Congo and the Central African Republic used a gravity model to estimate that goods traded via this route

¹⁶ Also, as with estimated travel-time savings, estimates of capitalized land values likely provide a lower-end range of benefits conferred by an improved road or transit facility. This is not only because accessibility improvements fail to capture external benefits (e.g., improved air quality) but also because they ignore some of the non-derived, psychological benefits of movement (Metz, 2008).

¹⁷ This might be done by using sales-transacted prices of formal, registered properties with similar levels of accessibility (based on regional location and proximity to transport infrastructure) as an informal property of interest, adjusting for differences in site (e.g., presence of piped versus non-piped water supply) and neighborhood (e.g., median income) characteristics. For more on shadow pricing of land market responses to transport-sector interventions, see Arnott and MacKinnon (1978).

would increase from a current value of US\$16 million to US\$142, nearly a 800 percent increase (Buysa et al., 2010). The study concluded that trade expansion promoted by the upgrading would exceed costs by about \$220 billion over 15 years, while generating millions of construction and maintenance jobs in some of Africa's poorest regions. While trade volume expansion is not a direct measure of welfare improvement, estimates of the growth and income-inducing effects of increased trade can reflect generative (as opposed to redistributive) benefits and thus should be weighed in investment decisions (Frankel and Romer, 1999).

7.4 COST-EFFECTIVENESS MEASURES

Rather than attaching a monetary value to transportation improvements, cost-effectiveness measures might be used instead. A cost-effectiveness metric might express the number of additional jobs that can be reached within one-half hour travel time per million dollar expenditure. Thus instead of attempting to assign a monetary value to benefits (e.g., increased access to jobs), only financial costs for project outlays are monetized. Combining data on financial expenditures with isochronic indices of accessibility can yield a reasonable performance measure that is free of such problems as valuing time or obtaining land valuation data.

Cost-effectiveness measures are likely better suited to many developing countries where reliable data are limited and outcomes are difficult to measure. Cost-benefit analysis is not used in evaluating public works projects — like a school building upgrade — when inputs cannot be easily translated to outcomes (e.g., higher student scores). Similar challenges in attributing transportation investments to accessibility outcomes argue for cost-effective measures as a second-best alternative in some instances.

8 CONCLUSION

The widespread and indiscriminant use of travel-time reductions as a stand-alone indicator of success in World Bank appraisals of urban transport projects is inconsistent with economic and spatial theories of how cities grow and function. In congested, fast-growing cities with a pent-up demand for mobility, unchecked sprawl, and correspondingly high induced-demand elasticities, travel-time savings is likely a poor measure of welfare benefits from transport interventions, policy changes, and capital investments.

The established practice of relying on time savings as the principal measure of economic benefit of urban transport projects needs to be questioned. Metz (2008, p. 324) echoes this view: "Data on average travel time offer no obvious support to the idea that travel time savings comprise the dominant element of the benefits from investments in the transport system". There is stronger evidence that people take advantage of transport system expansion in the form of additional access to desirable destinations, made possible by faster speeds within the fairly fixed budgets of time available for travel. Metz (2008, p. 325) adds that "given the long-term invariance of average travel time, travel time savings would necessarily be a transient phenomenon, in a context in which individuals tend to use improvements in the transport system to maximize access". Time savings is thus largely a short-term benefit. Over time, people tend to make longer journeys, not extra trips. Weighing impacts on accessibility thus brings a longer term perspective to the analysis, something that is needed given the fifty-plus year service life of most capital-intensive transport investments.

Concerns over induced travel, global warming, and auto-dependent cities call for a more balanced, holistic approach to evaluating future urban transport projects. Framing evaluations in terms of accessibility, not just mobility, allows a shift from a traditional engineering focus on speed and efficiency to a more balanced perspective that weighs environmental and social concerns as well. Additionally, assessing impacts on accessibility elevates the importance of land-use and demand-management strategies in the evaluation of alternatives. Besides accessibility and mobility (e.g., speeds), a more robust and inclusionary framework for measuring performance might also weigh factors like sustainability (e.g., VKT and emissions per capita), livability (e.g., community ratings or commute delays per capita), safety (e.g., road fatalities per 100,000 inhabitants), and affordability (e.g., percent wages spend on commuting) in judging proposals.

To date, accessibility has been treated qualitatively in most project appraisals of World Bank urban transport sector loans. It is not examined with the same rigor as projected travel-time savings. An evaluation of BRT proposals in Accra, Ghana, for example, used a qualitative scoring approach, subjectively giving "accessibility for low-income populations" a weight of 21.4% in judging competing corridors (World Bank, Africa Region, 2007). Many appraisals simply mention improved access in a list of "social benefits" as an adjunct to economic appraisals based mostly on savings in travel time and vehicle operating costs. Separating mostly quantified "economic benefits" from non-quantified "social benefits" gives the impression that accessibility impacts are

secondary and non-pecuniary.

Elevating the importance of accessibility and other performance measures like sustainability in project appraisals need to be done with equity concerns in mind. If improved access to jobs, shops, and hospital services are limited to car-owning households, little progress will be made in alleviating urban poverty. It is thus important that all performance metrics stratify results in ways that allow the likely distributional equity impacts of a project to be assessed. Additionally, measures of affordability should be directly used as an indicator, in and of itself.

Our choices for evaluation are fortunately not “either/or” — travel time savings or accessibility. In fairly homogeneous small-town settings where growth rates are modest thus few land-use adjustments might be expected, travel-time savings might be an appropriate way to gauge benefits. In others, say in fast-growing cities where induced demand phenomenon is alive-and-well, as much focus might be placed on measuring accessibility impacts. In tandem, travel-time savings and accessibility shifts provide a rich perspective for exploring the economic benefits of proposed transport projects. When supplemented by other outcome measures, like impacts on the environment, safety, and vehicle operating costs, the two can provide a fairly complete portrait of future economic benefits

9 NEXT STEPS

This paper argues for an enlarged, more inclusive set of indicators for evaluating transportation proposals in the developing world, most notably elevating the role and importance of accessibility improvements as a metric. How might this theory be put into practice? Given the reality that current appraisal methods are deeply entrenched and institutionalized, small, measured steps should be taken. Accordingly, a pilot demonstration is proposed. The aim should be to develop, refine, and apply a practical “tool-kit” of indicators for evaluating alternative urban transport proposals.

By way of illustration, this tool-kit might involve the following set of indicators:

First-Tier Indicators (with and without induced travel/induced growth adjustments):

- Total travel times
- Vehicle operating costs
- Collisions and accident injuries/fatalities

First-tier indicators could be measured using conventional methods, with the exception that adjustments would be made for estimated induced travel/induced growth impacts. Such adjustments might occur through feedback loops in 4-step models or through post-processing (i.e., applying induced travel/induced growth elasticities derived from comparable projects or provided as meta-analysis averages) [See: Cervero, 2006]. First-tier indicators might be further stratified by time-period (e.g., peak; all-day) and modes-of-travel.

Second-Tier Primary Indicators (with and without induced travel/induced growth adjustments):

- Environmental conditions (air pollution, noise pollution, visual impacts)
- Economic development impacts (employment, businesses, monetary value of private investments)

Second-order impacts generally reflect longer-term, delayed responses to changes in the urban transportation system. Conventional methods might be used, such as translating VKT and VHT impacts to air pollution levels using emissions-diffusion models. Economic development impacts might be estimated by applying techniques like shift-share forecasting, regional input-output modeling, or econometric/structural-equation modeling. Due to data and modeling limitations, more qualitative methods (e.g., expert-Delphi scoring) might be used in many developing country contexts to get at such hard-to-measure second-order impacts. In gauging impacts on economic development, care must be taken to distinguish those that are redistributive or pecuniary in nature versus those that are truly generative and income-

producing.

Second-Tier Supplemental Indicators (with and without induced travel/induced growth adjustments):

- Accessibility (jobs; medical facilities; education; retail-commercial)
- Sustainability (e.g., change in VKT per capita; change in VKT per motorist)
- Livability (e.g., percent change in trips by non-motorized transport by income strata; percent of peak-period traffic > 40 kph; percent green-space per capita; ratio of public green space to public impervious surfaces (i.e., parking and roads); lineal kms of bikeways/sidewalks per 10,000 inhabitants)
- Affordability (e.g., percent daily earnings spent on transport; mean monthly transit fare payments to mean monthly income)

These supplemental second-tier indicators round out the evaluation framework by accounting for a wider array of impacts that go beyond those affecting direct users of transport facilities or services. Depending on the availability of suitable data, accessibility impacts could be gauged using an isochronic cost-effectiveness measure (e.g., change in mean number of hospital and clinic beds that can be reached within 30 minutes by public transit — an indicator of “medical access by transit” — per \$1 million in investment costs). Or accessibility impacts could be monetized using hedonic-price methods. Alternatively, subjective scoring approaches might be used. In general, qualitative methods will need to be relied on to the extent that network-based travel-demand forecasting tools are unavailable for estimating impacts on VKT and VHT.

These multiple tiers of impacts are not additive. They represent overlapping Venn diagrams. Accordingly, trying to combine and force these metrics into a Cost-Benefit Analysis framework would be futile and yield erroneous results. Rather, consideration might be given to assigning relative weights to the indicators, based on local circumstances and expert opinions.

In closing, consideration should be given to pilot-testing and operationalizing the expanded evaluation framework presented in this paper. This would involve choosing a case site and project, identifying appropriate indicators based on local conditions and data resources, and carrying out the evaluation. Field testing is the best way to move the theories and ideas expressed in this paper one step closer to implementation.

REFERENCES

- Alonso, W. 1964. *Location and Land Use*. Cambridge, Massachusetts: Harvard University Press.
- Arnott, R. and MacKinnon, J. 1978. Market and Shadow Land Rents with Congestion. *The American Economic Review*, Vol. 68, No. 4, pp. 588-600.
- Banister, D. and Berechman, J. 2000. *Transport Investments and Economic Development*. London: Routledge.
- Barnes, G. and Davis, G. 2001. *Land Use and Travel Choices in the Twin Cities, 1958-1990*. Minneapolis, Center for Transportation Studies, University of Minnesota, Report No. 6 in series on Transportation and Regional Growth.
- Boarnet, M. 1997. Infrastructure Services and the Productivity of Public Capital: the Case of Streets and Highways. *National Tax Journal*, Vol. 50, No. 1, pp. 39-57.
- Boarnet, M., Kim, E., and Parkany, E. 1998. Measuring Traffic Congestion. *Transportation Research Record* 1634, pp. 93-99.
- Buysa, P., Deichmanna, W., and Wheeler, D. 2010. Road Network Upgrading and Overland Trade Expansion in Sub-Saharan Africa. *Journal of African Economics*, Vol. 19, No. 3, pp. 399-432.
- Cambridge Systematics, R. Cervero, and D. Aschuer. 1998. *Economic Impact Analysis of Transit Investments: Guidebook for Practitioners*. Washington, D.C.: National Academy Press, Transit Cooperative Research Program, Report 35, National Research Council.
- Casiroli, F. 2008. The Mobility DNA of Cities. *Urban Age*, December issue, pp. 1-3.
- Cervero, R. 2002. Induced Travel Demand: Research Design, Empirical Evidence, and Normative Policies. *Journal of Planning Literature*, Vol. 17, No. 1, pp. 3-20.
- Cervero, R. 2004. Effects of Light and Commuter Rail Transit on Land Prices: Experiences in San Diego County. *Journal of the Transportation Research Forum*, Vol. 43, No. 1, 2004, pp. 121-138.
- Cervero, R. 2005. *Accessible Cities and Regions: A Framework for Sustainable Transport and Urbanism in the 21st Century*. Berkeley: UC Berkeley Center for Future Urban Transport, Working Paper, UCB-ITS-VWP-2005-3. <http://www.its.berkeley.edu/publications/UCB/2005/VWP/UCB-ITS-VWP-2005-3.pdf>
- Cervero, R. 2006. Alternative Approaches to Modeling the Travel-Demand Impacts of Smart Growth. *Journal of the American Planning Association*, Vol. 72, No. 3, pp. 285-295.

- Cervero, R. 2010. Urban Reclamation and Regeneration in Seoul, South Korea. In: *Physical Infrastructure Development: Balancing the Growth, Equity and Environmental Imperatives*, W. Ascher and C. Kruupp, eds. Chapter 7. New York: Palgrave Macmillan.
- Cervero, R. and Hansen, M. 2002. Induced Travel Demand and Induced Road Investment: A Simultaneous Equation Analysis. *Journal of Transport Economics and Policy*, Vol. 36, No. 3, pp. 469-490.
- Cervero, R., Sarmiento, O., Jacoby, E., Gomez, L., and Neiman, A. 2009. Influences of Built Environments on Walking and Cycling: Lessons from Bogotá, *International Journal of Sustainable Transport*, Vol. 3, pp. 203-226.
- Cervero, R. and Kang, C. 2011. Bus Rapid Transit Impacts on Land Uses and Land Values in Seoul, Korea. *Transport Policy*, Vol. 18, pp. 102-116.
- Chalermpong, S. 2007. Rail Transit and Residential Land Use in Developing Countries: Hedonic Study of Residential Property Prices in Bangkok, Thailand. *Transportation Research Record* 2038, pp. 111-119.
- Choo, S. and Mokhtarian, P. 2008. How Do People Respond to Congestion Mitigation Policies? A Multivariate Probit Model of the Individual Consideration of Three Travel-Related Strategy Bundles. *Transportation*, p. 145-163.
- Cohen, H. and Southworth, F. 1999. On the Measurement and Valuation of Travel Time Variability Due to Incidents on Freeways. *Journal of Transportation and Statistics*
- Downs, A. 1962. The Law of Peak-Hour Expressway Congestion. *Traffic Quarterly* Vol. 16, pp. 393-409.
- Downs, A. 1992. *Stuck in Traffic*. Washington, D.C.: Brookings Institution.
- Downs, A. 2004. *Still Stuck in Traffic*. Washington, D.C.: Brookings Institution.
- Flyvberg, B., Holm, M., and Buhl, S. 2002. Underestimating Costs in Public Works Projects: Error or Lie? *Journal of the American Planning Association*, Vol. 68, No. 3, pp. 279-295.
- Frankel, J. and Romer, D. 1999. Does Trade Cause Growth? *American Economic Review*, Vol. 89, No. 3, pp. 379-399.
- Fulton, L., Meszler, D., Noland, R., and Thomas, J. 2000. A Statistical Analysis of Induced Travel Effects in the U.S. Mid-Atlantic Region. *Journal of Transportation and Statistics* Vol. 3, No. 1, pp. 1-14.
- Garrison, W. and Levinson, D. 2006. *The Transportation Experience: Policy, Planning, and Deployment*. New York: Oxford University Press.
- Giuliano, G. 1989. Incident Characteristics, Frequency, and Duration on a High Volume Urban Freeway. *Transportation Research*, pp. 387-396.

- Graham, D. 2007. Variable Returns to Agglomeration and the Effect of Road Traffic Congestion. *Journal of Urban Economics*, pp. 103-120.
- Gwilliam, K. 2003. Urban Transport in Developing Countries. *Transport Reviews*, Vol. 23, pp. 197-216.
- Handy, S. and Neimeier. 1997. Measuring Accessibility: An Exploration of Issues and Alternatives. *Environment and Planning A*, Vol. 29, pp. 1175-1194.
- Handy, S. and K. Clifton. 2001. Evaluating Neighborhood Accessibility: Possibilities and Practicalities. *Journal of Transportation and Statistics*, September/December, pp. 67-78.
- Heanue, K. 1997. Highway Capacity and Induced Travel: Issues, Evidence and Implications. *Transportation Research Circular* Vol. 481, pp. 33-45.
- Kang, C. and Cervero, R. 2009. From Elevated Freeway to Urban Greenway: Land Value Impacts of Seoul, Korea 's CGC Project, *Urban Studies*, Vol. 46, No. 13, pp. 2771-2794.
- Kitamura, R., C. Chen, and R. Narayanan. 1998. Traveler Destination Choice Behavior: Effects of Time of Day, Activity Duration, and Home Location. *Transportation Research Record* 1645, pp. 76-81.
- Koenig, J. 1980. Indicators of Urban Accessibility: Theory and Applications. *Transportation* Vol. 9, pp. 145-172.
- Kwok, R. and A. Yeh, 2004, The Use of Modal Accessibility Gap as an Indicator for Sustainable Transport Development, *Environment and Planning A*, Vol. 36: 91-936.
- Lefèvre, B. 2010. Urban Transport Energy Consumption: Determinants and Strategies for its Reduction; an Analysis of the Literature. *SAPIENS (Surveys and Perspectives Integrating Environment & Society)*, Vol. 2, No. 3, pp. 35-51.
- Mackie, P., Jara-Díaz, S., and Fowkes, A. 2001. The Value of Travel Time Savings in Evaluation. *Transportation Research E*, Vol. 27, No. 2, pp. 91-106.
- McLynn, J. and Spielberg, F. 1978. Procedures for Demand Forecasting Subject to Household Budget Constraints. Washington, D.C.: U.S. Department of Transportation, Federal Highway Administration, in *Directions to Improve Travel Demand Forecasting: Conference Summary and White Papers*, HHP-22, pp. 115-197.
- Metz, D. 2008. The Myth of Travel Time Savings. *Transport Reviews*, No. Vol. 28, No. 3, pp. 321-336.
- Miller, T. 1989. The Value of Time and the Benefit of Time Savings: A Literature Synthesis and Recommendations on Values for Use in New Zealand. Washington, D.C.: The Urban Institute.
- Mogridge, M. 1997. The Self-Defeating Nature of Urban Road Capacity Policy: A Review of Theories, Disputes and Available Evidence. *Transport Policy*, Vol.

4, No. 1, pp. 5-23.

Mohring, H. 1961. Land Values and the Measurement of Highway Benefits. *The Journal of Political Economy*, Vol. 69, No. 3, pp. 236-249.

Mokhtarian, P. and Chen, S. 2004. TTB or not TTB, That is the Question: a Review and Analysis of the Empirical Literature on Travel Time (and Money) Budgets. *Transportation Research A*, Vol. 38, No. 9, pp. 642-675.

Morris, E. 2007. From Horse Power to Horsepower. *Access*, Vol. 30, pp. 2-9.

Muller, P. 2004. "Transportation and Urban Form: Stages in the Spatial Evolution of the American Metropolis". *The Geography of Urban Transportation*, S. Hanson, ed. 3rd edition, Guilford Press, Chapter 3, pp. 59-85.

Muth, R. 1969. *Cities and Housing*. Chicago: University of Chicago Press.

Nishii, K. and K. Kondo. 1992. Trip Linkages of Urban Railway Commuters Under Time-Space Constraints: Some Empirical Observations. *Transportation Research B*, Vol. 26, No. 1, pp. 33-44.

Noland, R. and Small, K. 1995. Travel-Time Uncertainty, Departure Time Choice, and the Cost of Morning Commutes. *Transportation Research Record* 1493, pp. 150-158.

Noland, R. and Lem, L. 2002. A Review of the Evidence for Induced Travel and Changes in Transportation and Environmental Policy in the U.S. and U.K. *Transportation Research D*, Vol. 7, pp. 1-26.

Ory, D. Mokhtarian, P. Lothlorien, S., Salomon, I., Collanges, G., and Choo, S. 2004. When Is Commuting Desirable to the Individual. *Growth and Change*, Vol. 35, No. 3, pp. 334-359.

Parry, I., Walls, M., and Harrington, W. 2007. Automobile Externalities and Policies. *Journal of Economic Literature*, Vol. 45, No. 2, pp. 373-399.

Pickrell, D. 1992. A Desire Named Streetcar: Fantasy and Fact in Rail Transit Planning. *Journal of the American Planning Association*, Vol. 58, No. 2, pp. 158-176.

Rosen, S. 1974. Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. *Journal of Political Economy*, Vol. 82, No. 1, pp. 601-630.

Rouwendal, J. and Nijkamp, P. 2004. Living in Two Worlds: A Review of Home-to-Work Decisions. *Growth and Change* pp. 287-303.

Ryan, J. and Spear, B. 1978. Directions toward Better Understanding of Transportation and Urban Structure, Washington, D.C.: U.S. Department of Transportation, Federal Highway Administration, in Directions to Improve Travel Demand Forecasting: Conference Summary and White Papers, HHP-22, p. 199-247.

Salomon, I. and Mokhtarian, P. 1997. Coping with Congestion: Understanding the Gap Between Policy Assumption and Behavior. *Transportation Research D*, Vol. 2, No. 2, pp. 107-123.

Siegel, C. 2010. *Unplanning: Livable Cities and Political Choices*. Berkeley, California: Preservation Institute, ISBN 978-0-9788728-5-4.

Schaeffer, K.H. and Sclar, E. 1980. *Access for All: Transportation and Urban Growth*. New York: Columbia University Press.

Schrank, D., Lomax, T., and Turner, S. 2010. 2010 Urban Mobility Report. College Station, Texas: Texas Transportation Institute.

Small, K. 1992. *Urban Transportation Economics*. Chur, Switzerland: Hardwood Academic Publishers.

Small, K. 1999. Project Evaluation. *Essays in Transportation Economics and Policy: A Handbook in Honor of John Meyer*. Washington, D.C.: Brookings Institution Press, chapter 5, pp. 137-177.

Stopher, P. 2004. Reducing Road Congestion: A Reality Check. *Transport Policy*, pp. 117-131.

Tanner, J. 1981. Expenditure of Time and Money on Travel. *Transportation Research A*, Vol. 15, No. 1, pp. 25-38.

Törhönen, M. 2004. Sustainable Land Tenure and Land Registration in Developing Countries. *Computers, Environment and Urban Systems*, Vol. 28, No. 5, pp. 545-586.

Train, K. 2009. *Discrete Choice Methods with Simulation*. Cambridge: Cambridge University Press, 2nd edition.

Wachs, M. and Crawford, M. 1992. *The Car and the City: the Automobile, the Built Environment, and Daily Urban Life*. Ann Arbor: The University of Michigan Press.

Warner, S. 1962. *Streetcar Suburbs: The Process of Growth in Boston*. Cambridge, Massachusetts: Harvard University Press.

Weisbrod, G., Vary, D., and Treyz, G. 2001. *Economic Implications of Congestion*. Washington, D.C.: National Academy Press.

World Bank, Africa Region. 2007. *Project Appraisal Document on a Proposed Loan for the Republic of Ghana Urban Transport Project*, Report No: 39750-GH.

World Bank, Africa Region. 2009. *Project Appraisal Document for the Lagos Urban Transport Project 2*, Report No: 49974-NG.

World Bank, Latin American and the Caribbean Region. 2003. *Project Appraisal Document on a Proposed Loan for the Lima Transport Project*, Report No: 27253-PE.

World Bank, South Asia Region. 2002. *Project Appraisal Document on a Proposed Loan for the Mumbai Urban Transport Project*, Report No: 24004-IN.

Zahavi, Y. 1979. *Travel Over Time*. Washington, D.C.: U.S. Department of Transportation, Federal Highway Administration, Report PL-79-004.

Zahavi, Y. and Talavittie, A. 1980. Regularities in Travel Time and Money Expenditures. *Transportation Research Record* 750, Transportation Research Board, pp. 13-19.



Transport Division

Transport, Water and
Information and Communication
Technology Department

The World Bank

1818 H Street NW

Washington DC 20433

USA

www.worldbank.org/Transport

DFID Department for
International
Development

