Division 44
Water, Energy and Transport

Demystifying Induced Travel Demand

Sustainable Urban Transport Technical Document # 1

By Roger Gorham

gtz Transport Policy Advisory Services

On behalf of
Federal Ministry
for Economic Cooperation
and Development

About the author

Roger Gorham is an urban transport specialist with a background in urban planning and extensive experience in climate change and air quality analysis. He has previously worked as a transport and land-use specialist for the US Environmental Protection Agency, as a researcher with the Lawrence Berkeley National Laboratory, and as a transport consultant attached to various international organizations and the private sector. He is currently a Transport Economist with the World Bank.

His long-term research interests have been coordination of transport and land-use, assessment of travel behavior and the bi-directional influence between land-use and travel behavior, and the role of travel behavior change in mitigation of GHG and local pollutant emissions. He has also had a long-term interest in improving travel forecasting practices, and making these arcane techniques more accessible and less prone to manipulation to advance interested outcomes.

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Chapter 1. Introduction

The concept of "Induced travel demand" is often described or portrayed in lay discussions of the topic, and in the popular media, thusly: "If we build it, they will come." Travel demand unfolds from transportation investment in a deterministic manner: we build, they come.

But that simplistic description belies the complexity of the phenomenon of induced travel. If we build anything, will they come? Or will they come only if we build a particular "it"? And who are "they" that will "come" — people who are not coming at all right now? Or people who are coming, from time-to-time, but would come more often if we build "it"? Perhaps most importantly, if we don't build "it", would they come anyway?

This last question cuts to the heart of the most important conceptual and philosophical debates surrounding the phenomenon of induced travel demand. Is building "it" causing them to come, or is there some other reason? After all, demand for many things — including land and transportation — grows naturally as economies expand and incomes grow, whether or not infrastructure is built. These kinds of questions give rise to rather heated debates between induced travel "skeptics" and believers.

The induced travel skeptic tends to argue that the growth in demand for space, housing, goods, services, and consequently mobility, is quite simply a natural outcome of economic growth. Responsible public policy needs to accommodate that natural growth, and should not be constrained by claims of induced growth. After all, if "they" are coming anyway, don't we have an obligation to build it? Doesn't accepting the notion of induced demand imply a need to put a chill on economic development entirely?

On the other side of the spectrum, environmental and some social advocates ask leading questions in the opposite way. If travel demand is indeed "induced" by infrastructure development, then is building or expanding road facilities — especially as a means to relieve congestion — merely a futile exercise feeding a vicious circle, since the additional capacity simply gets filled up by induced traffic? Aren't we simply spending good money after bad to come to essentially the same end (congested roadways), only poorer (because the money that was invested in the facility expansion could have been invested elsewhere), and at an order-of-magnitude greater (because now more people are affected by congestion and more vehicles are jammed up and emitting pollutants)?

These questions have manifested themselves in debates about roadway expansion in the developed world for years, but increasingly, they are being raised in the context of developing country cities as well. For years, there was a common perception in developing countries that acute congestion in cities was related to a lack of resources for investment in transportation facilities — that infrastructure was not "keeping pace" with growth in demand, because of resource constraints associated with the national levels of GDP. However, experience in cities as varied as Cairo, Shanghai, Santiago, and Sao Paulo has shown that infrastructure investment *per se* does not necessarily reduce levels of congestion.

This technical document is intended as an introduction to the concept of induced travel demand and the principal arguments and debates surrounding the phenomenon. While it tries to remain neutral in the normative debates about whether induced travel is a "good" or a "bad", it does accept as a fundamental premise, and argues emphatically, that induced travel demand is a real and measurable phenomenon, that it can and does produce environmental and social consequences, and that it should be *explicitly* accounted for in project evaluation and strategic assessments wherever possible.

1.1 Why induced demand seems so complex

The concepts, tools, and methodologies needed to evaluate and understand induced travel tend to be rather sophisticated and can seem to the uninitiated to be extremely complex and opaque.

Fundamentally, however, induced travel demand is actually quite a simple concept. It is a natural phenomenon that occurs as people respond to changes in the amount of time it takes them to travel around. Whether traveling around the neighborhood, across the country, or around the world, people will shift their patterns of movement — when, where, how, and how often they make a trip — in response to their perceptions of how easily they can move around in a transportation system. Those responses occur whether the change affects cars, trains, buses or airplanes. A similar phenomenon occurs relative to freight movements; production and logistics managers will make decisions about the logistics associated with manufacturing and delivery of goods — the mix of warehousing and shipping associated with product output — based on their perceptions of how quickly and cheaply goods can be moved around. As these perceptions change (based in part on changes to the network they observe occurring around them), so will their decisions.

One reason that the phenomenon of induced travel has seemed so complex is that its recognition has required a fundamental shift in the dominant paradigm of transportation planning that has dominated the field since the end of World War II, and this shift itself has been difficult. The United States has been particularly influential in developing the tools and methodologies of transportation planning used throughout the world, including in developing country cities. In the paradigm of transportation planning that dominated professional thinking in the US in the 1950s, basic travel patterns were assumed to be fixed. Transportation planners' primary role was to try to forecast what those patterns would be in some future year, and propose a rational set of transportation system improvements that would accommodate them. Over the past twenty years or so, increasing numbers of transport practitioners have been reassessing this paradigm, but not always smoothly and with different results in different places. Many have begun to understand travel patterns as dynamic and interactive with the transportation system; supply and demand influence each other. Other transportation planners continue to operate under the paradigm that future-year travel patterns should be predicted, and that their role is simply to “find” the right set of transportation investments to meet those patterns, even though they may recognize that transportation investments can influence those patterns. Still other transportation planners continue to believe that patterns of demand are fixed and knowable, regardless of the quantity and type of transportation investments made.

In addition, notwithstanding the slow paradigm shift by practitioners, many of the tools they have available — and particularly tools in widespread use in the developing world –remain grounded in the old paradigm. These tools — represented most predominantly by the 4-step, Urban Transportation Planning (UTP)-based demand-forecasting models — were largely created during the decade of 1950, and were structured fundamentally around the old-paradigm notion of “predict-and-provide". To be sure, they have been modified and improved upon, and alternative methodologies exist, but the vast majority of travel forecasting models in use are structured at their core on the idea that transportation investments have no influence of future patterns of travel demand.

1.2 Why call attention to induced travel?

Many transportation professionals argue that induced travel demand is simply part and parcel of travel demand as a whole, and that those who identify it or call it out as a separate phenomenon are not simply misstating its importance, but rather misunderstanding the art and nature of travel demand forecasting. Many factors influence how travel demand grows, including, but not limited to, policy and infrastructure changes, and it is the job of travel demand forecast specialists to take all of these factors into account as best as they can.

Under ideal circumstances, this argument would be valid. Travel demand and behavior specialists indeed should be taking all of these factors into account. In practice, however, transport projects are often driven not by technical specialists, but rather by political factors and economic interests. These interests often favor particular “solutions” to transport problems even before the problems themselves are well described or documented, or various potential solutions are evaluated against

each other on a level playing field. In these politically charged contexts, the under- or over-estimation of future travel resulting from induced travel — and even its outright exclusion in some situations — is a common technique used to bias the results toward a favored outcome. Questions of induced travel get buried in the obscurity of travel demand forecasting techniques, often referred to as the great **Black Box** of urban transport. The more private sector participation funding gets drawn into the funding of urban transport infrastructure (light rail transit, urban expressways, etc.) in developing countries, the greater the risk that under or overestimation of induced travel will be used to favor particular outcomes.

To counter these interests, municipal governments, decision-makers, and citizens groups looking after the public interest need to develop a more sophisticated response to these techniques. The best defense is to shine a light into the **Black Box**, to name the phenomenon, and demand accountability. This technical document is intended to serve as a first step toward that end.

Chapter 2. What is induced travel demand?

Induced travel demand is about time; specifically, it's about how people respond when the amount of time it takes for them to go from one place to another is reduced. Traditional transportation demand analysis assumes that speed improvements simply result in a reduction in the time people spend traveling. "If I can travel faster than before, then I'll simply get to my destination sooner, and reduce the amount of time I spend traveling." In traditional economic analysis, this "reduction" in travel time is assumed to be a benefit to all travelers, linked to the value that traveler places on the amount of time spent traveling. That value can be measured using Stated or Revealed Preference techniques of conjoint analysis.

In reality, however, people's reactions to a reduction in the time needed to travel from point A to point B may be substantially more complex. To be sure, some travelers might reduce the amount of time they spend traveling, but others might choose to travel farther, that is, to different destinations, or more often. They might change the proportion of trips they make by different modes, depending on how speed improvements affect the different modes differently. Over time, they might even choose to situate themselves differently in an urban area. "If I can travel faster than before, then I can get to a destination slightly farther away in the same amount of time, or I can make more trips to the grocery store in the same amount of time, or I can live or work somewhere else." Similarly, production managers in industry might change the way they value the tradeoff between transport and warehousing, or in the longer run, might make changes in where they site their production or distribution facilities, in response to particular or generalized travel time changes. In aggregate, the details of the workings of induced demand can be complex, and valuation controversial, but at its core, it is a straightforward concept: people respond to changes in travel time by changing their behavior.

2.1 Induced travel defined

The time to travel between one point and another is one of a number of travel conditions that describe a trip. Others include the safety of the trip (or the perception of safety), comfort, reliability or frequency of a service, etc. Broadly understood, ***induced travel demand is any increase in travel resulting from improved travel conditions.*** Travel is considered *induced* if it can be shown that there is more travel occurring when an improvement to one or more of those travel conditions occurs than would be the case if that improvement or those improvements did not occur. In the vast majority of cases where induced travel is a concern the particular improvement in travel conditions in question is an improvement in travel time — that is, either a reduction in travel time, an improvement in the reliability of travel time, or both. Therefore, for simplicity in the exposition that follows, ***this technical paper will use the term "induced travel demand" to indicate any increase in travel resulting from a reduction in travel time or the variability of travel time.***

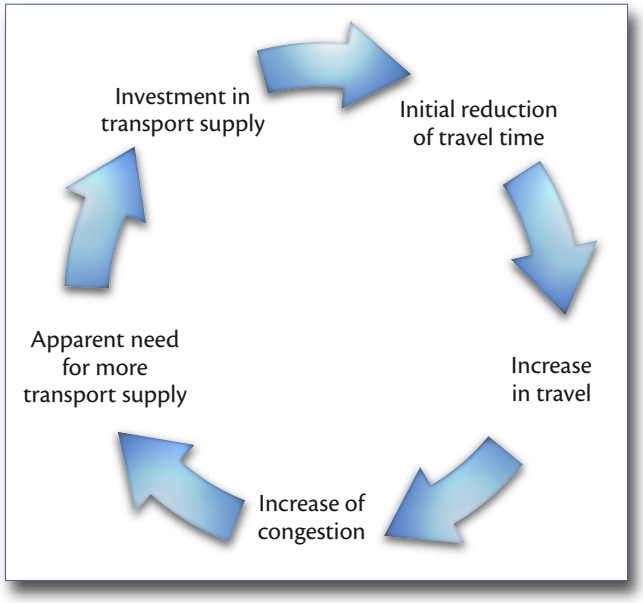

Figure 1: Induced travel's vicious cycle

This definition of induced travel demand is conceptually straightforward, but difficult to address. Who is increasing their

travel, and how do we know that it "results" from a reduction in travel time and/or travel time variability? How do we measure average travel times and variability? How do we know that these phenomena have been "reduced"? "Reduced" from what? These ambiguities can become problematic unless the concept of induced travel is refined or operationalized for particular contexts. For now, however, we leave a broad definition in order to continue to build the conceptual understanding of the phenomenon. We will also focus only on passenger travel in order to develop these concepts (the phenomenon, however, is equally as robust in the freight sector).

2.2 Characteristics of induced travel

Before diving into the theoretical and practical explanations of how induced travel actually works, it is worth pausing to note several important characteristics about the phenomenon of induced travel as implied by the above definition. Understanding these characteristics is critical to ensuring that induced travel not be mischaracterized in technical discussions.

Characteristic 1. **Induced travel at the metropolitan level is concerned with travel as a whole, not trip-making *per se***

- Induced travel does not necessarily result from people making more or more frequent *trips*. Rather, the term refers to the overall amount of travel that is undertaken. Lay-people and transportation professionals often refer inadvertently to changes in "trip-making" when discussing induced demand (*e.g.* "induced trips"). At best, such references are a kind of shorthand used by professionals who may thoroughly understand the issue, but find such terminology easier to manage in discussions among themselves. More commonly, though, use of such terminology may suggest that the user does not have a good grasp of the subject. For example, one frequently hears the notion expressed "I don't believe induced travel is real, because it defies logic that people will make more trips simply because travel time is reduced." Such an expression shows that the speaker confuses induced travel as a phenomenon of discrete trips, rather than aggregate travel.

Characteristic 2. **The concept of induced travel applies to the entire transportation sector, not just to one mode**

- Improvements in air travel or public transport are just as capable of creating induced demand as improvements to road facilities. In public transport, for example, increased ridership might be observed in response to travel time reductions achieved through more frequent or more direct services, as well as to reductions in passenger fares and improvements in perceived comfort and safety. Travel can also be induced *across* modes. For example, extension of commuter rail services into previously undeveloped areas may induce market demand for particularly low-density housing that necessitates car travel for discretionary (non-work) trips. Similarly, provision of high speed rail between two cities might *increase* the amount of car travel between them, because it increases economic or lifestyle interactions.

Characteristic 3. **Induced travel is not the only source of growth in the demand for travel**

- The notion that induced travel represents an increase in travel resulting from an improvement in transportation conditions implies that there are increases in travel that do *not* result from improvements in transportation conditions. These increases in travel *not* resulting from improvements in transportation conditions are referred to as "natural demand growth", in contrast to "induced travel demand". It is critical, both conceptually and practically, to distinguish between the two. There are many factors that cause demand for transportation services to grow naturally, including changes in population, employment, income, socio-demographics, and tastes, attitudes and relative distribution of different age cohorts.

Characteristic 4. **Induced travel can *only* be understood with reference to a hypothetical "base" case or counterfactual**

- Induced travel cannot be evaluated simply by looking at how actual conditions evolve; on the contrary, by definition, induced travel demand describes how current conditions would have been different had other choices been made in the past or how future conditions will differ among alternative scenarios. We use the term "counterfactual" to refer to the hypothetical alternatives against which the phenomenon of induced demand is measured. The whole concept is shown in Figure 2.

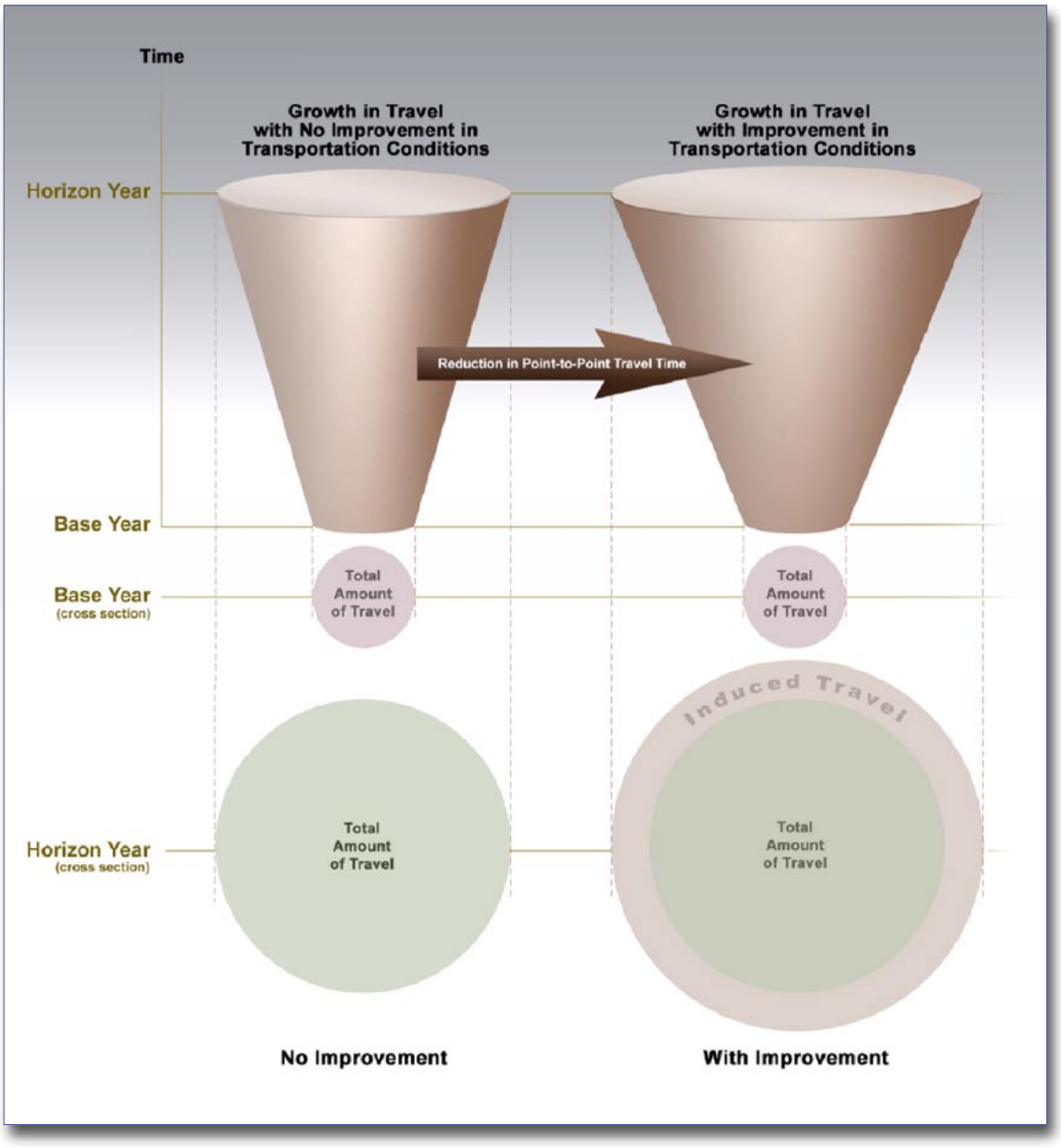

Figure 2: Induced demand in counterfactual analysis

2.3 Theoretical explanation of induced travel

The concept of induced travel is fully consistent with microeconomic principles of supply and demand. For consumers, transportation entails costs, namely, out-of-pocket (monetary) costs of the trip, the "opportunity cost" of the time spent traveling (*e.g.* lost leisure time, lost wages), and, in some accounting frameworks, some portion of the fixed or "sunk" costs they may have already

paid for time-related unlimited access to a transportation means (such as owning and maintaining a vehicle, or acquiring a monthly transport pass, etc.). For simplicity, we will ignore this last cost in the following analysis. The "opportunity cost" of time spent traveling is the component that is of interest to us here. Even though there is often no monetary transaction associated with this phenomenon, frequently called the "value-of-time" by transport economists, it does have real economic value: consumers are willing to pay some amount of money to avoid time spent traveling.

Collectively, all of these costs are referred to as the "generalized costs" of travel. Changes to the transportation network which reduce the time-cost of travel — adding capacity or providing completely new services, for example — have the effect of reducing the generalized costs of travel. The laws of supply and demand teach us that, as prices go down, the quantity demanded goes up. The increase in demand resulting from the reduction in generalized cost of travel is what we can call induced travel demand.

Recall, however, the fourth characteristic from Section 2.2 above. Induced travel must be understood with reference to a counterfactual, not to an actual evolution of conditions. When we talk about consumer response to a "reduction" in the generalized cost of travel, we do not literally mean an actual reduction over time, but rather a relative difference in generalized cost between two hypothetical scenarios — or one real and one hypothetical scenario — at the same point in time. It may not matter whether a particular transport investment actually reduced the travel time of any particular traveler in reality; what matters is whether the investment results in point-to-point travel times that are lower than they otherwise would be for a scenario without the investment, at the same point in time.

The role of counterfactuals in this analysis cannot be overemphasized. What it means is that, while we can analyze induced travel theoretically, and infer its magnitude using a variety of tools, we can never actually observe it or measure it directly in the real world. This inability to directly observe the induced travel demand phenomenon, unfortunately, has led to some strange and extreme conclusions about induced travel, ranging from claims that it does not exist (*i.e.* it is "simply" part and parcel of natural demand growth) to claims that all growth in travel demand is induced (*i.e.* "traffic simply fills up" any new capacity). Both claims run counter to well-accepted principles of how markets function.

Textbox 1: Other language sometimes used to describe or evoke the concept of induced travel

This Technical Document endorses the use of the term "induced travel demand" to refer to additional demand for travel associated with an improvement in travel conditions. However, many authors use other terminology to describe or evoke the concept. Some of these terms are discussed briefly below. While this document does not endorse the use of these terms in discussions about induced travel, it is useful for the reader to be familiar with the terms and recognize that users of these terms are often referring to some aspect of what this Technical Document calls induced travel demand.

▶ Generated traffic/generated travel

"Generated traffic" or "generated travel" is a common term used in the literature — particularly in technical studies — to refer to induced travel. In travel forecasting, however, the notion of "generation" has a specific meaning: travel that is produced or attracted to particular locations in a transport network as a function of characteristics of that locale (*e.g.* household, land-use, and/or activity-pattern characteristics.) Transport facilities' "generation" of traffic or travel is a misnomer, therefore. More importantly, the terms "generated traffic" and "generated travel" remove the human element. Transport facilities do not generate transport activity. People generate transport activity, but they can be induced to undertake more or less activity based on generalized costs, which are at least partly determined by transport services, facilities, and the network in which they operate.

▶ Latent demand

"Latent demand" is a term applied to discussions of induced travel with surprising regularity. It is sometimes referred to as "suppressed demand", and often related to the erroneous substitution of the discrete phenomenon "trips" for the continuous phenomenon "travel" in violation of Characteristic #1 of induced travel discussed in Section 2.2. Litman, for example, defines latent demand as "additional trips that would be made if travel conditions improved" (Litman 2009). In this sense, Litman's use of the term "latent demand" refers specifically to induced trip-making.

Evidence from the United States, however, suggests that induced trip-making is virtually non-existent. (See Rodier 2002, Rodier *et al.,* 2001, Mokhtarian, *et al.,* 2002.) Most induced travel effects are associated in the short run with changes in trip-destinations, and in the longer run with land-use changes in reaction to changes in accessibility. It is possible that in rapidly growing urban areas in the developing world, or in highly congested conditions where that congestion occurs over a significant portion of the day, there would, indeed, be more induced trip-making in response to an improvement in travel conditions than has been observed in studies of the US and Europe, but there is little empirical evidence at the present time. Even so, the more neutral term "induced trip-making" should be preferred to the term "latent demand".

The concept of latent demand evokes a notion of underlying, "pent-up", or "frustrated" demand for transport that consumers may have, but are unable to exercise because a service is either not offered or its generalized costs are too high — usually, the time-cost associated with an "inadequate" transport system. The notion of demand "latency", therefore, is an emotionally laden term — what stands between the public and the fulfillment of their "demand" is a politicians' decision to invest (or not) in a given transport facility or service. That "latent demand" for trips or travel gets "released" when new capacity is created, analogous to the relationship between potential and kinetic energy.

But latent demand has no economic meaning. In economics, demand simply refers to the aggregate number of times that people have the means and willingness-to-pay for a good or service in the marketplace. To be sure, economics recognizes that demand and supply are closely interrelated — supplying new goods or services can foster demand for them — but the notion of demand "latency" is both conceptually suspect and technically imprecise, particularly where the underlying "service" is simply a reduction in point-to-point travel time.

For normal goods, the laws of supply and demand imply that lowering prices increases

demand. If we reduced the price of a hamburgers at a fast-food restaurant from $1.25 to $1.00, we would expect to see an increase in demand for hamburgers, both because people might substitute hamburgers for other food (what economists call the “substitution effect”) and because they might consume more hamburgers since they have more money in their pockets (what economists call the “income effect”). However, the notion that these income and substitution effects reveal some kind of “latent” demand for hamburgers is prima facie absurd. People would consume even more hamburgers if they were all free. Should we then say that “latent demand” for hamburgers is the amount of hamburgers people would consume if they were free?

The same is true with travel. To be sure, as Litman’s definition implies, there may be more trip-making if travel conditions improve, because people might substitute travel for, say, making a phone call, or obtaining a service on the internet (although even here, people are more likely to substitute a longer trip for a shorter one), and they may make additional trips because they have more time on their hands, but to suggest that such behavior changes represent some notion of demand “latency” is not an approach consistent with micro-economic analytical methods.

Such methods begin with the premise that goods and services (including transport services) have costs associated with them, that people have budgets (including budgets for their time) and that they make choices based on those budgets, their preferences, and the prices they face. In the hamburger example, people decide how many hamburgers to buy as a result of all these factors, not because they have some underlying, absolute "latent" demand for hamburgers. The parallel in transportation analysis is that people weigh their time and out-of-pocket costs against competing uses for those resources, their preferences, and the "costs" they see in terms of how long it takes them to travel from point A to point B, and they make their travel choices accordingly. In the words of University of Chicago economist Steve Levitt, "Most of economics is actually about individual human behavior. Faced with a set of constraints, what decisions do we make to do the best we can for ourselves?" (Levitt and Dubner 2005).

Because of its emotion-laden qualities and its analytic inappropriateness, therefore, this Technical Document recommends avoiding using the term "latent demand" in discussions of transport policies and options, even when referring to specifically to trip-making.

Chapter 3. How does induced travel occur?

The discussion of induced travel up until now has been somewhat abstract; the previous chapter defined and explained the concept of induced demand, and presented a broad theoretical justification for its existence as a real phenomenon, but we have said very little about the actual mechanisms that cause it.

Those mechanisms can be quite complex and tortuous; there are multiple "pathways" by which induced demand can occur, so much so that untangling them can require sophisticated data collection techniques, analytical skills and mathematical simulation models of transportation and urban systems. In a strictly economic sense, the details of this analysis are arguably irrelevant; indeed, an economist might even argue that trying to untangle the sources of induced travel adds an unnecessary layer of complexity to the analysis of transport problems, that simply understanding the basic dynamics of supply and demand is sufficient to be able to diagnose and remedy the problem.

In practice, though, planners, engineers and increasingly, environmentalists — not economists — grapple on the front lines with questions about induced travel, so we must be able to frame the discussion in their terms. Planners and engineers, for example, tend to be the practitioners that use the modeling and forecasting tools (sometimes well, sometimes poorly) that could quantify induced travel demand if applied properly.

We mentioned at the beginning of this technical document that induced travel is fundamentally about time, so time is a good conceptual entry point into this discussion, as shown in Figure 3. Imagine that the transportation and land-use network is a pond, calm at equilibrium, and that a measure that reduces point-to-point travel time (like a new service, or a widened roadway) is dropped into this pond. That pebble is represented by the travel-time reduction in the center of the diagram; it produces ripple effects that propagate throughout the transportation and land-use "pond" over time. These ring waves propagate out from the most immediate reactions to the pebble, to the most diffuse and longest term: short-run diversions, changes in trip destinations, changes in selection of vehicles to own and use on a day-to-day basis, changes in the location choices of households and firms, and changes in the development patterns that real estate markets produce.

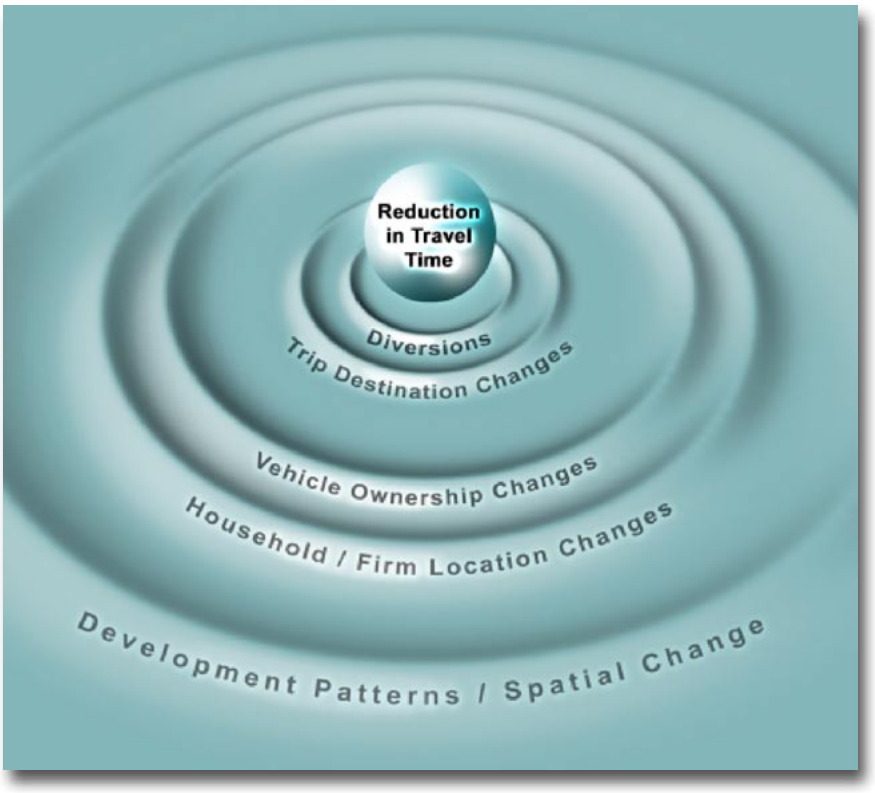

Figure 3: Ripple effect of induced demand

To help organize the discussion, we distinguish these effects as direct and indirect, and instantaneous, short-run, and long-run effects. These distinctions are admittedly somewhat arbitrary; reasonable people can disagree about which effect falls in which category.

3.1 Direct induced travel

Direct induced travel, generally refers to *conscious decisions* by travelers, or potential travelers, to take advantage of real or perceived changes in point-to-point travel time by altering travel patterns in a manner that increases overall travel. These decisions, in turn, can occur over different time frames, which we collapse into three: instantaneous, short-run, and long-run.

- Instantaneous traveler responses. Travelers or potential travelers can respond to changes in capacity essentially immediately, by diverting their transportation behavior in one of three distinct ways, in a process Downs (2002) refers to as "triple convergence":
  - Temporal convergence — people might change the times they choose to embark on a trip;
  - Spatial convergence — people might change their choice of route;
  - Modal convergence — people might change the mode by which they travel.

In all three cases, people respond to a perceived change in travel time by changing their behavior on particular trips. (Or, to be more literally consistent with Characteristic 4 of the definition of induced travel given above, people engage in trip-making behavior that is different than their hypothetical, counterfactual selves *would have* engaged in, had the change in capacity not occurred.)

- Short-run traveler responses: In the short-run, travelers or potential travelers can respond to changes in point-to-point travel times by altering their trip-making patterns in a number of different ways.
  - Trip destinations — people might select a different set of destinations to which to travel, particularly for *discretionary* (non-work) trips. Since these destinations are substitutes for an existing set of destinations, and point-to-point travel time would have decreased while time available for travel would not have, it is likely that substituted destinations would involve travel to farther-away destinations.
  - Trip chaining patterns — people might change the way they chain stops together when they leave their house, for example by combining errands less and "running out" more.
  - Trip frequency — people might change how often they make trips, for example, by shopping for groceries each day rather than stocking up for the week.

In all three cases, people respond to a perceived change in travel time by changing their overall patterns of trip-making. (Or, in the literal language of the 4th characteristic of induced travel, they engage in different trip-making patterns than they otherwise would have had the change in transport capacity not occurred.)

- Long-run traveler responses: In the long-run, travelers or potential travelers might decide to change the locations where they live or work to take advantage of reductions in point-to-point travel time. In aggregation, these changes in demand for locations can, in turn, affect real estate markets and the locations that developers or local planning councils pull into the market.
  - Households might relocate their residence to more outlying areas;
  - Employees might change their work location to more outlying areas;
  - Employers might move their businesses to more outlying areas (which can, in turn, encourage yet more relocation and decentralization);
  - Developers, in response to these pressures, might reorient or accelerate development of residential subdivisions, retail centers, and office, industrial and technology parks in outlying areas.

In all of these cases, people respond to a perceived change in travel time by changing their base of operations within the metropolitan area. (Or, in terminology consistent with the 4th Characteristic of induced travel, they locate in different places than their hypothetical, counterfactual selves would have, had the change in transportation capacity not occurred.)

3.2 Indirect induced travel

Indirect induced travel refers to increases in transportation activity that would not have occurred if a particular transportation improvement had not occurred, but which are not the results of conscious choices made by travelers or potential travelers in response to the perceived change in travel time or reliability. At least three mechanisms can be identified by which indirect induced travel occurs: network effects, lifestyle effects, and market effects.

- *Network effects*: Decisions by travelers or potential travelers taken in response to *other people's* collective responses to changes in point-to-point travel time is potentially an important source of induced travel demand. These network effects can be complex, and tricky to represent in — or tease out from — standard modeling and/or micro-simulation packages. An example of a network effect is the decision of a trip-maker to use an arterial — either as a new route to an old destination or as a new destination — when traffic congestion along that arterial is alleviated in response to the opening of a new, parallel motorway segment. In this example, induced travel demand manifests itself in a location other than where the capacity expansion actually occurs, and because of behavior by an individual who never actually experiences the direct impact of that transportation improvement.
- *Lifestyle effects*: Lifestyle effects refer to decisions by travelers or potential travelers to make changes in response to transportation improvements that actually amount to wholesale or partial lifestyle changes — changes that, in turn, can cause people to undertake more travel than if they did not change their lifestyles. Two such examples are changes in vehicle ownership, and changes in residential location.

Vehicle Ownership. The desire to take advantage of a reduction in travel time by car may induce some households or firms to purchase additional vehicles in order to substitute car or two-wheeler travel for travel previously made by other modes. As discussed in Section 3.1, the travel associated with these trips would be considered direct-effect induced travel. However, by owning a car that the household might otherwise have chosen to do without, members of the household might make additional trips by car not related to the purpose for which the car was purchased, thereby resulting in additional travel that is induced indirectly.

The additional travel is associated with a *fixed-cost effect.* Fixed costs are transportation-related costs that are paid out periodically, irrespective of actual use. They include expenses such as vehicle acquisition, registration, insurance, and vehicle storage. They contrast with *variable costs*, which are costs paid on a per-use basis, such as gasoline, tolls, parking charges, and, in the case of purchased transportation services, fares. All else equal, the greater the share of total costs that are attributable to fixed-costs, the more travel that will occur, because, perversely, the average cost per trip or per kilometer traveled can be *reduced* by increasing the total number of trips or kilometers traveled. In other words, transportation investments and policy decision that induce households to make lifestyle decisions that entail a relative shift in transportation expenditures from variable to fixed costs can be expected to lead to an increase in transportation activity, all else equal.

Residential location. Classical urban economics teaches that households trade-off between housing and transportation costs (Alonso 1964). As transportation costs change, so, too, do the costs of land. Changes in point-to-point travel time, therefore, can cause shifts in land values in different parts of a city. Households may relocate in response to these price changes, so that their overall "transportation and housing budget" is the same. Any change in the distance traveled per trip as a result of this relocation might be considered a manifestation of *direct-effect* induced travel — individuals make a decision that causes travel to go up.

That said, however, once the household relocates, it may be constrained into making *other* transportation choices that also increase travel. Consider a household that moves from a central neighborhood in a metropolitan area to one on the outskirts in response to the construction of a radial freeway. In the classic, single-worker family model, the transportation logic of the head-of-household

may be the driving force behind the decision to move (*i.e.* travel time to and from work before and after the move for this individual is the same.) The additional travel this individual undertakes in the journey to work from the new location, therefore, might be called direct induced travel. But the other members of the household may find that they also need to increase the amount of travel they undertake, simply to maintain the same level of accessibility they had when they lived in closer to the center (*e.g.* more trips by car, more distance traveled, or both). This additional vehicular travel can be considered indirect induced travel.

- *Market effects:* Just as transportation investments can alter households' calculations for accessibility and tradeoff of land-values, they can also affect strategic market calculations for firms. In particular, they affect the calculus of the firm's access to labor pools, and to retail and service customer bases. The aggregated effect of these strategic decisions can constrain households into traveling farther than they otherwise would have, had such strategic decisions not been induced by infrastructure changes.

Firms and retailers often decide where to locate in a metropolitan area based upon assessments of "catchment" areas for particular labor or customer market niches. For example, a retailer with an overall strategy of being within 20 minutes' travel time of 50,000 potential customers will base his decisions on where to locate in a metropolitan area on the particularities of the transportation network, and can be expected to be sensitive to changes in that network. All else equal, the more extensive the transportation infrastructure network, the fewer separate establishments the retailer needs in order to comply with that strategy.

By pursuing this strategy, retailers can inadvertently induce travel in several ways. First, as they close intermediary and superfluous stores, in response to changes in the transportation network, they may constrain large numbers of households into traveling farther (in distance, if not in time) than they would need to in the counterfactual scenario in order to attain the same level of access to retail opportunities. Second, if the sum effect of these strategic decisions is to reduce the density of retail opportunities (*e.g.* retail space per square kilometer), such changes may accelerate the imperative of households to acquire a car or motorized two-wheeler, since locally available retail options that do not require private motorized transport may disappear over time. This accelerated rate of vehicle ownership, in turn, increases the lifestyle effect of indirect induced travel.

As Chapter 2 highlighted, it is difficult to even quantify induced travel in the real world, let alone try to parse it into direct and indirect sources. Clearly, however, some portion of induced travel perceived by policy makers and the general public comes from indirect sources such as the network, lifestyle, and market effects. As a result, induced travel is sometimes assumed, erroneously, to be synonymous with land-use change or metropolitan "sprawl". To be sure, they are related phenomena, in that many of the same behavioral changes give rise to both. But sprawl and land-use change is a complex phenomenon in its own right, with its own processes and logic. Confusing these two phenomena inhibits the ability to accurately characterize and evaluate either. Rather, they should be thought of as separate but mutually influencing processes, both of which can cause environmental damage and carry economic costs often not accounted for in project assessments.

3.3 Induced and diverted travel

The preceding discussion has largely sidestepped the oft-divisive question of whether "diverted" travel ought to be considered as part of induced travel writ large, or whether it is necessary to define them to be mutually exclusive. Some experts in the field argue that the term "induced travel" should be understood to include only "generative" travel — that is, travel that can be described as "truly new". In their view, diverted or redistributed travel — that is, traffic might have occurred anyway, either at some other place or at some other time of the day on that network — should not be considered to be induced travel. Some authors have even tried to introduce specific terminology to make this distinction. (See, for example, the distinction between "Induced" and "Generated" travel in Litman (2009))

The problem with this approach is that it is unlikely that all users of the term "induced travel" will have the same understanding of the term, or will necessarily use it exclusively to mean generative rather than generative plus diverted travel, no matter how many articles get written trying to assert a definition one way or the other. In some contexts, that distinction may not even be particularly relevant. If his constituents are frustrated by what they perceive as a rapid growth in demand following the widening of a freeway, a local council member may not particularly care if this traffic growth occurred as a result of diverted, rather than generative, travel. He or his constituents might very well refer to the entire phenomenon as "induced travel", to the ire of the purists.

While it is critical for any working definition of "induced travel" to be meaningful and consistent in particular contexts, as a general phenomenon, it is not possible to assert a definition for all contexts beyond the broad definition proposed in Chapter 1 — that is, any increase in travel associated with a reduction in travel time, the variability of travel time, or both. Sometimes the term will be used in ways that include diverted travel, and in other contexts it is appropriate to try to eliminate as much as possible the inclusion of diverted travel. It is the responsibility of the user of the term to expound and operationalize the term so as to avoid ambiguity.

Not only is it not possible to police the use of the term, but there are also a number of other reasons for avoiding a dogmatic specification in the generative versus diverted travel debate. First, it is possible to draw an evaluation frame so broadly that virtually *all* travel appears as a diversion, just as it is possible to draw that frame so narrowly that virtually all appears to be generative. For example, an analysis may focus on turning movements of private vehicles at a particular intersection during a single AM peak hour on Tuesdays. That frame would make *any* change in travel patterns look like generative travel. Drawing a wider evaluation frame — looking at more hours or more days, covering more parts of the network, covering more types of vehicles, etc. — would make much of what looks like generative travel under the narrow first frame of reference appear as diverted travel under the second. But even at a very broad frame of reference — for example, looking at annual travel for an entire metropolitan area and all modes — it is still possible to "zoom out" to an even broader frame in which generative travel actually appears as diverted activity. In an activity and accessibility-based approach, for example, "generative" travel writ-large could be understood as a *diversion* of *activity* that would have occurred anyway somewhere, including inside the home. In other words, the question of diverted versus generative travel is largely a line-drawing debate, and there is neither an overriding guiding principle nor a consensus about where to draw those lines.

Second, from the standpoint of environmental assessment, both diverted and generative travel can have deleterious effects on environmental outcomes. Truly new travel increases the volume of vehicle kilometers producing emissions and other environmental effects, but redistributed travel can also increase the volume of vehicle kilometers producing emissions, if modal shifts (for example, away from public transport and toward driving alone) increase aggregate numbers of vehicles on the roadway. In addition, redistributed travel can contribute to congestion, thereby changing the emissions profile per vehicle kilometer traveled. It is more important to ensure that such effects are explicitly accounted for in environmental, social, and economic analyses than to quibble about whether they are labeled "induced" or "diverted" travel effects. To enable such analysis, the range of potential diversions — modal, spatial, temporal, and activity-based — should be explicitly accounted for and discussed in project scoping.

Chapter 4. How should induced travel be addressed in policy, planning and project development cycles?

Questions and controversies about induced travel might surface at any point in the policy, planning and project development cycles. However, the closer to project implementation that the subject comes up, the least amount of room for maneuver planners have to address it. Consequently, while it should be an explicit part of evaluation at all phases of development, it should be particularly emphasized during the most strategic phases of public policy analysis.

This chapter addresses generally the consideration of induced travel in particular phases of the overall project development cycle: during strategy formation of different urban growth options, in the process of forecasting travel demand, in the economic valuation of transportation alternatives, and in the environmental assessment process.

4.1 Strategic assessment of urban growth options (visioning)

Few metropolitan areas in the developing world undertake truly strategic assessment of options for urban development growth, particularly from the standpoint of examining the role of transportation. A notable exception is Amman, Jordan. The situation is a little better in the developed world — particularly certain cities in Western Europe, Canada and the United States — but even in these countries, strategic options analysis is by far more the exception than the rule.

Recognition of induced travel can be an important component in helping to determine which among a series of alternative transportation investment strategies at the metropolitan level can best obtain agreed upon goals over the long run. At the level of strategic assessment, the room for maneuver in response to induced travel and induced land-use change is the greatest. For example, analysts can determine whether accessibility enhancement along a corridor is best addressed through roadway improvements, public transport enhancements, land-use and design treatment of spaces along that corridor, or some combination. Honest assessment of likely induced travel — or an evaluation of the risks to development goals from induced travel — can help determine which alternative is most likely to advance a certain set of goals for the least cost.

At the strategic assessment level, the interaction between induced travel and land-use changes can also be better assessed than further downstream in the policy/project cycle. Changes in the structure of demand — origin/destination patterns — that result from travel time reductions will affect development pressures in different parts of the metropolitan area, and the likely changes in land development patterns that result will also have further influence on origin/destination patterns. In more downstream analysis, the ability to adequately assess and understand these interactions may be sharply curtailed, leading to poor understanding of how transportation investments actually affect land-use and travel time interactions.

4.2 Travel demand forecasting

Forecasting travel demand is often at the heart of the technical contribution of planners and transport engineers to the transportation planning process. Sometimes it is carried out *ex ante*, to inform decision-making, but, unfortunately, it is equally, if not more, often carried out to justify, *ex poste*, decisions already taken. The elaborate models used to generate these forecasts are often ideal tools to do so, because they can be procedurally and mathematically complex, and therefore opaque to the general public and decision-makers. The misrepresentation of induced travel in these models, therefore, is one of the key mechanisms by which politically motivated decisions can be "justified" as technically sound even if, when implemented, they produce none of the benefits promised. In particular, there is a danger that induced travel is over-estimated for certain public transport projects (particularly trunk-line service investments through low-density areas) and under-estimated for road projects (particularly urban radial and ring-roads).

That said, travel demand forecasting techniques are *crucial* to truly understanding induced travel demand, because, as discussed in Section 2.3, induced travel can *never* be observed directly, but rather only deduced by reference to a counterfactual situation, a counterfactual which is most consistently derived via travel demand models. Getting the representation of induced travel right in this process, therefore, is a key part of the induced travel debate.

There are two general approaches improving induced travel assessment using off-the-shelf travel demand models based on the conventional 4-step approach. One is to improve the models themselves (and the data used to feed the models) in order to produce more accurate representation of induced travel in the models' output. The second is to use the models more strategically to help define the limits of tolerance of the transport system to induced travel demand. This second approach borrows from the techniques of risk analysis. These two approaches are compatible, and used together, can greatly reduce the uncertainty associated with induced travel demand.

It is worth highlighting that one fundamental and structural weakness of travel demand forecasting practice is that the spatial distribution of activities in a metropolitan area for a given year (often referred to as "land-use") is usually determined *exogenously*, that is, they are presented to the travel demand model as assumptions. As discussed in Chapter 3, however, a key premise of induced travel demand is that employers, developers, and households may alter where they carry out activities over time, in response to a change in transportation conditions. Uncorrected, these models would not accurately reflect long-run induced travel, because they would not reflect the influence of the transportation system on location decisions giving rise to particular OD patterns. There are a number of methods to correct for this shortcoming, but discussion of such methods are beyond the scope of the current Technical Document.[1)]

4.3 Economic valuation of transportation projects

The economic evaluation of transportation projects and investments is often an important part of the feasibility study phase of the project. At the core of the economic evaluation process is usually either a comparison of the cost-effectiveness (the cost required to produce particular units of benefits) among different measures, or a comparison between the expected costs and expected benefits of a measure or set of measures. In both cases, the aggregation of benefits for the analysis depends on accurate relative forecasts of transportation demand, which, in turn, will be inaccurate if induced travel demand is overlooked or poorly accounted for.

Better representation of induced travel in travel demand models, therefore, as discussed briefly in the previous section, is a first step in improving the economic valuation of transportation projects, because the output of these models often serves as the basis on which economic analysis is made. That said, however, the economic techniques often used for the valuation of transport projects in general — and induced travel in particular — are themselves highly suspect, even where the travel forecasts are relatively accurate. These techniques tend to be trip-based (*i.e.* they attribute *inherent* value to trips and trip-making, whether or not such value has been determined empirically) and they tend to inappropriately apply a rule of thumb derived from welfare economics — the so-called "Rule of Half". In most cases, the combined effect of these two suspect techniques is probably to overestimate the benefits, and underestimate the costs, associated with induced travel, particularly for road projects in urban areas.

As a result, the state of the practice is such that the theoretical framework for the economic valuation of induced travel demand is poorly developed, and in dire need of additional work. Ideally, such a framework would have the following characteristics:

- It would be *activity-* or *productivity-based*. Economic value would be gauged according to differences in participation levels of different activities, or differences in the quality of available

[1)] See for example Bartholomew 2005 or Fehr and Peers 2007 for further reference.

activities for participation, rather than measures of trips or travel *per se*, between or among two or more alternatives.

- Based on these activities, it would compare the net marginal individual and social costs of the induced vehicle kilometer to the net marginal individual and social benefits of changes in levels of activity participation, or the quality of choices of those activities.
- It would evaluate the opportunity cost of the capital devoted to the investment causing the induced travel in the first place, particularly with respect to stated and implied purposes of the project.

The practice of economic evaluation in the transportation sector is far from these ideals. There are substantial methodological and data hurdles that would need to be overcome to meet these ideals. Perhaps because of these hurdles, the World Bank, in a series of "Economic Notes" on economic evaluation in the transport sector, recommended as recently as 2005 the continued use of trip-based analysis combined with misapplication of the Rule of Half.

4.4 Environmental assessment

Induced travel also figures prominently in environmental assessments of transportation projects, particularly with respect to the analysis of local air quality and, as is likely to be the trend in the coming years, accounting of greenhouse gas emissions as well. A common argument for investing in facilities that expand the effective capacity of roadways in particular is that slow speeds — and the stop-and-go traffic that produces it — increase each vehicle's pollutant emissions, and decrease its operating and energy efficiency. By increasing traffic speeds, and/or smoothing the flow of traffic on the network, the emissions profile of each vehicle will be reduced.

Leaving aside that such arguments tend to oversimplify the technical characteristics of vehicles that operate on internal combustion, on its own it is a specious argument as a technical justification for capacity expansion, precisely because induced travel demand is often left out of the calculus. Pollution is the sum effect of *all* vehicles on the road, so even if the emissions profile of a kilometer of driving produced by an individual vehicle is reduced as a result of capacity expansion, that reduction may be partially or entirely offset by changes in the total volume of vehicle kilometers produced. Those changes in total volume, in turn, may mean that the traffic characteristics that are forecast to occur might, in fact, not occur, or, if they do occur, could do so for briefer periods during the day than expected, or may not last as long as anticipated. These changes, in turn, will feedback to affect the emissions profiles of individual vehicles. Without accounting for induced travel demand, then, not only are the aggregate numbers of vehicles producing pollution misestimated, but it is also not even possible to accurately characterize the emissions profiles of individual vehicles, because the level of service of the facility may turn out to not be as predicted.

To truly understand the impacts of induced travel demand on local air quality, traffic volumes feeding emissions models need to accurately reflect induced travel. Again, these volumes tend to be generated by travel demand forecasting models, which sit upstream in airshed analysis as shown in Figure 4.

From the above diagram, it can be seen that misdiagnoses of travel demand — including induced travel — propagate through the entire process. A similar process occurs in the evaluation of GHG emissions from transport.

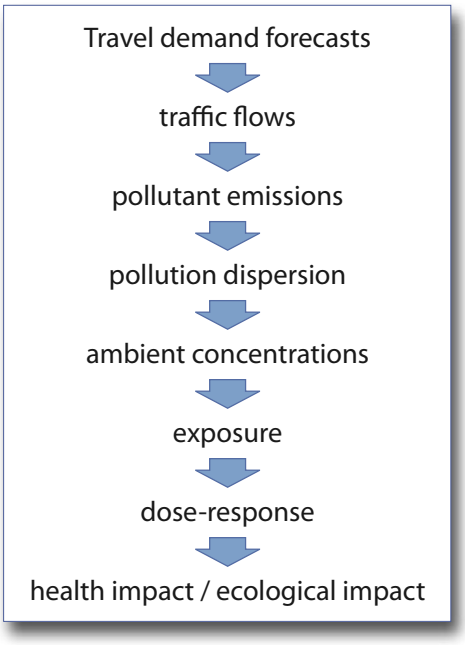

Figure 4: Airshed analysis

4.5 Better accounting for induced travel

We have seen that accounting for induced travel affects all levels of policy and project analysis, from strategic visioning of alternatives to environmental assessment of projects. A number of principles can help in the assessment of induced travel in this evaluation cycle.

Account for induced demand upstream. Account for induced travel as early as possible in the development cycle, using as broad a range of techniques as practicably feasible. This can include using tiered assessments or other techniques to make strategic assessments prior to committing to particular investment solutions.

Operationalize early. Operationalize a definition of induced demand early in any assessment, and seek agreement from stakeholders regarding this operationalization. The earlier the source of future ambiguity and/or controversy can be avoided, the smoother the assessment process will go.

Account for all environmental impacts. Account for all impacts, whether or not they are formally included in a definition of induced travel. If trips diverted along a different path to a common destination are not counted as induced demand, their impacts on the environment nevertheless need to be counted. Make sure you are not double-counting impacts.

Ask specific, pointed questions of the travel demand modeler about how induced demand has been taken into account not just in the travel model itself, but in his or her particular run of the model for the exercise or evaluation in question. In particular, make sure the modeler can describe:

- Whether trip-distribution (and ideally trip start times and mode shares, as well) is (are) sensitive to changes in travel time — that is, whether, in the model, travelers are given the opportunity to change where they go (and, ideally, when and how, as well) as a function of a change in travel time. (Often, lazy modelers or those under pressure for an "expedited" result will only allow travelers to change their routes based on travel time, but not their fundamental destinations.)
- Whether land-uses are assumed to be the same in some horizon year regardless of how zone-to-zone trip times change.

If the modeler cannot convincingly explain his approach to these phenomena, it is likely that induced travel has been given short shrift in the forecast and in any subsequent analysis based on it.

Avoid piece-meal analyses. Analyze projects or groups of projects in totality in order to assess cumulative impacts. Don't analyze project phases separately, which can tend to understate impacts.

Address normative questions through participatory processes. Encourage visioning exercises that address normative visions for metropolitan growth patterns, but divorce these from discussions of induced demand. Do not allow discussions of induced demand to stand in for discussions about how a metropolitan region should grow.

Key references

- ***Barr, Lawrence*** (2000)," Testing For the Significance of Induced Highway Travel Demand in Metropolitan Areas" in Transportation Research Record. No. 1706 (2000), p. 1–8.
- ***Bartholomew, Keith*** (2005), Integrating Land Use Issues into Transportation Planning: Scenario Planning. Available at: **http://faculty.arch.utah.edu/bartholomew/SP_SummaryRpt_Web.pdf**
- ***Boarnet, Marlon*** (1997), Direct and Indirect Economic Effects of Transportation Infrastructure. Irvine: University of California Transportation Center.
- ***Boarnet, Marlon*** (1997), "New Highways & Economic Productivity: Interpreting Recent Evidence" in Journal of Planning Literature, Vol. 11, No. 4, May 1997, pp. 476–486.
- ***Boarnet, Marlon and Saksith Tan Chalermpong*** (2002) New Highways, Induced Travel and Urban Growth Patterns: A "Before and After" Test, Paper 559. Irvine: University of California Transportation Center.
- ***Cambridge Systematics*** (2003), WFRC Model Sensitivity Testing and Training Study. November. Salt Lake City: Wasatch Front Range Regional Council.
- ***Cervero, Robert*** (2003), "Road Expansion, Urban Growth and Induced Travel: a Path Analysis" in Journal of the American Planning Association. Vol. 69, No. 2 (Spring 2003).
- ***Cervero, Robert and Mark Hansen*** (2002), "Induced Travel Demand and Induced Road Investment: A Simultaneous Equation Analysis," in Journal of Transport Economics and Policy No. 36 (2002), pp. 469–490.
- ***Chu*** (2000), "Highway Capacity and Areawide Congestion." Preprint for the 79th Annual Meeting of the Transportation Research Board. National Research Council, Washington, D.C.
- ***Department of Environment, Transport and the Regions*** (1994), Guidance on Induced Traffic, Guidance Note 1/95, HETA Division, 14th December 1994.
- ***Douglass Lee, Lisa Klein and Gregorio Camus*** (1999), "Induced Traffic and Induced Demand" in Transportation Research Record 1659 pp. 68–75. Washington D.C. Transportation Research Board.
- ***Downs, Anthony*** (1992), Stuck in Traffic: Coping with Peak-Hour Traffic Congestion, The Brookings Institution: Washington, DC.
- ***Fehr and Peers*** (2007), An Assessment of Integrated Land Use/Transportation Models. Southern California Association of Governments.
- ***Fulton, Lewis M, Robert B. Noland, Daniel J. Meszler, and John V. Thomas*** (2000), "A Statistical Analysis of Induced Travel Effects In The U.S. Mid-Atlantic Region" in Journal of Transportation and Statistics, Vol 3. No. 1 (April 2000), pp. 1–14.
- ***Goodwin, Phil B.*** (1996), Empirical evidence on induced traffic, a review and synthesis, Transportation, 23: 35–54.
- ***Goodwin, Phil and Robert B. Noland*** (2003), "Building New Roads Really Does Create Extra Traffic: A Response to Prakash *et al.*," Applied Economics.
- ***Hansen, M. D. Gillen, A. Dobbins, Y. Huang, and M. Puvathingal*** (1993), The Air Quality Impacts of Urban Highway Capacity Expansion: Traffic Generation and Land-Use Change. Institute of Transportation Studies. Berkeley: University of California.
- ***Hansen, Mark and Yuanlin Huang*** (1997), "Road Supply and Traffic in California Urban Areas" in Transportation Research Part A: Policy and Practice. Vol. 31A, No. 3 (May 1997).
- ***Heanue, Kevin*** (1998), Highway Capacity and Induced Travel: Issues, Evidence and Implications, Transportation Research Circular, no. 481, Transportation Research Board, National Research Council.

- ***Hills, Peter J.*** (1996), What is induced traffic?, Transportation, 23: 5–16.
- ***Kroes, E P, Daly A J, Gunn H F and van der Hoorn, A I J M*** (1996), "The Opening of the Amsterdam Ring Road" in Transportation Vol. 23, pp. 71–82.
- ***Levitt, Stephen and Steven Dubner*** (2005), Freakonomics: A Rogue Economist Explores the Hidden Side of Everything. New York: William Morrow.
- ***Litman, Todd***. (2009), Generated Traffic and Induced Travel. Victoria Transport Policy Institute.
- ***Marshall, Norman*** (2000), "Evidence of Induced Demand in the Texas Transportation Institute[1]s Urban Roadway Congestion Study Data Set," presented at Transportation Research Board Annual Conference, Washington, DC. Jan. 2000.
- ***Marshall, Norman and Brain Grady*** (2001), Draft Induced Travel Results. Resource Systems Group for the U.S. Environmental Protection Agency, 2001.
- ***Mokhtarian, Patricia,*** *et al.,* (2002), "Revisiting the Notion of Induced Traffic Through A Matched-Pairs Study," Transportation, Vol. 29, pp. 193-202.
- ***Noland, Robert B.*** (2001), Relationships Between Highway Capacity and Induced Vehicle Travel, Transportation Research A, 35(1): 47-72.
- ***Noland, Robert B. and William A. Cowart*** (2000), "Analysis of Metropolitan Highway Capacity and the Growth in Vehicle Miles of Travel" in Transportation Vol. 27 No. 4, pp. 363-390.
- ***Rodier, Caroline J.*** (2002), A Case Study of Induced Travel in the Sacramento Region using a Travel Demand Model and an Integrated Land Use and Transportation Model. Report for ICF Consulting and the US Environmental Protection Agency. Washington: US Environmental Protection Agency, Office of Transportation and Air Quality 2002.
- ***Rodier, Caroline J., John E. Abraham, and Robert A. Johnston*** (2001), Anatomy of Induced Travel: Using an Integrated Land Use and Transportation Model, paper no. 01-2582 presented at the 80th Annual Meeting of the Transportation Research Board.
- ***SACTRA*** (1994), Trunk Roads and the Generation of Traffic. Standing Advisory Committee on Trunk Road Assessment. London: Department of Transport (United Kingdom). UKDoT, HMSO.
- ***Schiffer, Robert, Walter Steinvorth, and Ronald Milam*** (2005), "Comparative Evaluations on the Elasticity of Travel Demand." Paper 05-0313, presentation at TRB annual meeting in 2005, Transportation Demand Forecasting Committee. Washington, Transportation Research Board (**http://www.trb-forecasting.org/trb2005papers.html**).
- ***Strathman, James G., Kenneth J. Dueker, Thomas Sanchez, Jihong Zhang, and Anne-Elizabeth Riis*** (2001), Analysis of Induced Travel in the 1995 NPTS Final Technical Report to the US Environmental Protection Agency, Office of Transportation and Air Quality.

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