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16. Abstract

Transportation projects and policies are rooted in economic considerations and consequences. This report documents the development of a relatively comprehensive transportation economics reference for practitioners, entitled *The Economics of Transportation Systems: A Reference for Practitioners*. This guidebook is tailored for those on the front lines of transportation planning, design, and policy at state Departments of Transportation and elsewhere, so that they can more easily anticipate and evaluate the economic implications of their work. In addition to introducing key transportation economic terms and concepts, the Reference describes a wide variety of tools for project and policy evaluation and analysis, to help transportation professionals address fundamentally complex questions with more confidence, particularly under resource constraints. The Reference's contents address issues ranging from appropriate contractor charges for project delays to optimal budget allocation across capacity-expansion and maintenance projects, and speak directly to the day-to-day needs of practitioners. The Reference's provision of transportation economics fundamentals, analytical methods, and case studies illustrate the endless opportunities for successful economic considerations and applications within transportation.

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A Transportation Economics Reference for Practitioners: Final Report

Kara Kockelman
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Chapter 1. Introduction

1.1 Purpose

While many transportation planners and engineers feel unfamiliar with economic principles, their job duties frequently involve economic decision-making. Often these decision processes appear casual in nature, emerging based on past engineering judgments and rules of thumb. Nonetheless, they are rooted in economic considerations and consequences. Fundamentally, travel is an economic activity and good economic judgment is vital to transportation planning and engineering.

This project's objective was to develop a comprehensive yet reasonably concise Transportation Economics Reference tailored for Texas Department of Transportation (TxDOT) personnel to appreciate the economic implications of their work and assess such impacts for more optimal decision-making. (The resulting document, entitled *The Economics of Transportation Systems: A Reference for Practitioners*, 0-6628-P1, was published in February 2013.) Key Reference topics include cost estimation, economic impact analysis, assessment of travel-time savings and related productivity impacts, transportation externalities, comprehensive project evaluation and budgeting, road pricing policies, welfare economics, and econometric tools. Such concepts provide the foundation for a solid understanding of transportation economic theory and thoughtful applications for specific network contexts.

In addition to introducing key transportation economic terms and concepts, the Reference presents a wide variety of evaluation and analysis tools to help transportation professionals address fundamentally complex questions with more confidence, particularly when facing ever-tighter resource constraints. The Reference's illustrations of various economic concepts are designed to help TxDOT personnel more holistically and rigorously evaluate transportation investment opportunities and policies. Since many of TxDOT's goals are economic in nature, equipping TxDOT personnel with a customized guide to better achieve the agency's mission will help address the state's transportation needs and aspirations.

1.2 Organization of Report

The organization of this report largely follows the chronological order of the project work that resulted in the Reference. The project's first year was largely devoted to the creation of the core Reference chapters (including assembling relevant materials, developing an organizational structure through an evolving table of contents, and creating core chapter content). The second year focused on developing case study applications to demonstrate the economic concepts introduced in the core chapters and creating supplementary presentation slides for the related workshops. Both years involved strong outreach to transportation economics experts and professionals across the state and around the globe, to obtain as much feedback as possible to enhance Reference content.

Chapter 2. Generating Reference Content

2.1 Assembling Relevant Source Materials (Project Task 1)

Transportation enjoys important economic roles in local and regional economies. Understanding the micro- and macro-economic impacts of transport policies and investments at the local, regional, state, national, and international levels enables better decision-making. Designed to be a comprehensive document, the Reference strives to convey established understanding in transportation economics, and illustrate core content via examples and case study descriptions. The research team gathered many relevant materials for core content of the Reference, taking a two-prong approach to compiling a long list of content sources. First, the research team conducted an extensive literature review of transportation economics texts. Then, experts in areas of transportation economics were consulted, as described below.

2.1.1 Literature Review

During the team's literature review, recognized texts on transportation and economic theory—such as Small and Verhoef's *The Economics of Urban Transportation*, Button's *Transport Economics*, Boyer's *Principles of Transportation Economics*, and Jara-Díaz's *Transport Economic Theory*—were used to establish fundamental concepts for Reference coverage (including various chapters' emphases and order). These texts, along with National Cooperative Highway Research Program (NCHRP) and Transit Cooperative Research Program (TCRP) synthesis reports, Victoria Transport Policy Institute (VPTI) documents, FHWA primers, and state DOT guidebooks, all include extensive Reference lists; these lists helped steer the research team to a variety of detailed analyses and meaningful case studies. Critical appraisal and analysis of these studies and reports enabled identification of the most useful resources for the Reference's content.

To improve readability for TxDOT personnel, the sources also include lecture notes from Dr. Kara Kockelman's Transport Economics course and Dr. Fernanda Leite's Project Management and Economics course. The manner through which information is conveyed in the course notes matches the Reference's illustrative focus on terms, concepts, and examples, while helping guide a logical flow of Reference topics. For Texas-specific case studies and examples, the research team worked with Center for Transportation Research (CTR) library staff to identify previous TxDOT reports and other articles related to Texas transportation and economic issues. These then complemented many case studies the team had originally proposed, before project work began.

2.1.2 Obtaining Expert Perspectives

In addition to establishing existing knowledge, the Reference addresses many strengths and weaknesses of current practices and studies. While materials identified during the literature review helped shape the Reference's content and organization, expert perspectives helped identify the strengths and limitations of existing work, identify gaps in content, provide informed views on controversies that can arise in the literature, and direct the research team to the latest cross-topic case studies to best illustrate economic concepts in transport.

Nuances in specific topics were clarified via consultation with external experts (e.g., welfare assessment with Dr. Kenneth Small and transportation costs and benefits with Robert Harrison) and internal project advisors (e.g., economic impact analysis with Dr. Leigh Boske).

Other experts made valuable suggestions to content additions (e.g., Todd Litman's suggestion to focus on accessibility versus mobility and Dr. Gerard de Jong's suggestion to include freight transport and logistics).

2.2 Structuring Table of Contents (Project Task 2)

Based on the initially proposed table of contents, extensive, literature reviewed and expert feedback, the research team identified relevant topics and sub-topics for the Reference and developed an enhanced table of contents. The Reference's initial draft organization was influenced by the organization of the Button (1997) and Small and Verhoef (2007) texts, and contained 17 chapters (each containing concept descriptions and example applications to maximize reader understanding and facilitate implementation of core ideas).

To evaluate this new table of contents, the draft table of contents was sent to the following experts.

- Ken Cervenka, FTA, Washington, D.C.
- Dr. Patrick DeCorla-Souza, FHWA, Washington D.C.
- Dr. Gerald de Jong, Professor of Transport Economics, University of Leeds
- Dr. Robin Lindsey, Professor of Economics, University of Alberta, Canada
- Todd Litman, Victoria Transport Policy Institute
- Chris Porter, Cambridge Systematics, Boston
- Dr. Sharada Vadali, Texas Transportation Institute, College Station
- Dr. Erik Verhoef, Professor of Spatial Economics, Free University, The Netherlands
- Chris Williges, System Metrics Group, San Francisco

In addition to these experts, the team submitted the draft table of contents to TxDOT staff members for review. Detailed feedback on the table of contents was obtained from many TxDOT staff members via phone interviews and email surveys. Open-ended questions about TxDOT work that may involve economics and about projects that could serve as case studies were posed to the following staff members:

1. Raul Cantu
2. Jack Foster
3. Ron Hagquist
4. Brandy Huston
5. Matt Kalinowski
6. Bonnie Lister
7. Matt McGregor
8. Scot Sullivan

9. Peggy Thurin
10. Ann Zeeck

By integrating suggestions of economics experts and TxDOT staff members, the research team restructured the table of contents (while still containing many of the original topics) to a format with large umbrella topics and distinct sub-topics, to better meet the expressed interests and needs of TxDOT staff. The final table includes eight core chapters under three broader topics: microeconomics of transportation, transportation planning and policy, and methods for analysis. As an additional feature for the reader, an introductory chapter was added to the beginning of the Reference, serving as an executive summary. Less technically detailed than the later chapters, this overview chapter demonstrates for readers the interconnectedness of the Reference's various topics and their economic relationships and impacts. For readers interested in specific concepts, this overview offers a roadmap to the technical details and specific case studies covered in the Reference's later chapters. Some of its contents are provided here, to highlight this lead-in to the Reference itself:

"I am an engineer, so I never use economics—do I?"

Transportation planners and engineers often feel unfamiliar with economic principles, and some assume that economics does not apply to their job duties. In practice, most transportation professionals can regularly employ economic concepts and techniques for decision-making—and many do, albeit unconsciously. Due to a variety of time and data constraints, many transportation practitioners' decision-making processes are not formally documented and emerge via "engineering judgment." However casual in nature, the wisdom behind such judgment comes from past experiences and is rooted in economic considerations and consequences. In fact, many "rules of thumb" for transportation investment and policy arose from economic backgrounds.

Consider this example: due to pavement aging and regular use, many farm-to-market (FM) roads are in need of rehabilitation or reconstruction. Should TxDOT districts install more expensive but longer lasting concrete pavements or rely on less expensive asphalt overlays? The rule of thumb is to go with asphalt, for a variety of reasons, but a definitive answer is not simple. If strict near-term *budget constraints* did not exist, the decision presumably would be based on a *life-cycle cost analysis*, used to reveal the solution that yields the lowest annual equivalent cost or maximum *net present benefit* over a long-term horizon, reflecting *risk and uncertainty* in flow volumes, materials prices, vehicle sizes, and other economic indicators. In the face of tight budgets, immediate *tradeoffs* loom. Asphalt pavements may be favored simply to ensure a consistent level of pavement quality across the district under limited funding conditions, while emphasizing *equity* in funds disbursement—thus covering more funding requests in a given year. However, if certain FM roads carry significantly more truck traffic, and some are in areas with high levels of black clay (which causes premature distress on asphalt pavement and so requires higher maintenance costs), should these roads be candidates for concrete pavements? What if such a consideration requires some lighter-traffic roads to be maintained less frequently? What is the cost passed onto the users of the lighter-traffic roads who may experience slower *travel times* and increased *vehicle repair and maintenance costs*? This common topic is rife with economic considerations.

Fortunately, a wide variety of tools is available to help transportation professionals address these common but fundamentally complex questions with more confidence than a rule of thumb offers.

2.3 Developing Core Chapter Contents (Project Task 3)

In concert with the literature reviewed and expert perspectives obtained, the team developed a first draft of the Reference that totaled 307 pages. Diverse in nature, key topics include costs and benefits of transportation, pricing of transportation services, regulation and competition, transportation impacts on land use, project financing and evaluation, economic impact analysis, and econometric analysis of transportation data. In addition to these eight fundamental chapters, an initial overview chapter provides motivation, highlights key concepts from each chapter, and illuminates connections between related contents across chapters. At the end of the Reference, a Data Sets chapter provides a list of existing private and public U.S. data sets, which are useful for economic analyses of a tremendous variety of transportation questions.

2.3.1 Expert Review

The team contacted 15 established experts to provide review and substantive feedback on the chapters and topics that best matched their areas of expertise. These individuals are as follows (with associated chapters shown in parentheses):

- Dr. Ken Button, George Mason University (Ch. 4 and 5)
- Ken Cervenka, Federal Transit Authority (Ch. 1 and 2)
- Patrick DeCorla-Souza, Federal Highway Administration (Ch. 3 and 4)
- Dr. Michael Lahr, Center for Urban Policy Research, Rutgers University (Ch. 7 and 8)
- Dr. Robin Lindsey, University of British Columbia (Ch. 2 and 3)
- Todd Litman, Victoria Transportation Policy Institute (Ch. 1 and Data Sets)
- Dr. David Luskin, Federal Highway Administration (Ch.1 and 7)
- Dr. Bill O'Brien, University of Texas at Austin (Ch. 6)
- Dr. Juan de Dios Ortúzar, University of Chile (Ch. 8)
- Elena Safirova, Resources for the Future (Ch. 4 and 7)
- Dr. Ken Small, University of California at Irvine (Ch. 8)
- Dr. Erik Verhoef, University of Amsterdam (Ch 2. and 3)
- Glen Weisbrod, Economic Development Research Group (Ch. 1 and 7)
- Dr. Jack Wells, USDOT (Ch. 5 and 6)
- Chris Williges, System Metrics Group (Ch. 6)

The research team received substantial feedback from Todd Litman, Patrick DeCorla-Souza, and Michael Lahr. As one response to such feedback, a summary table of all benefits and

costs of transportation was added to Chapter 1 (Costs and Benefits of Transportation) and a recommended list of statistical modeling software programs was added to Chapter 8 (Econometrics for Data Analysis). Moreover, lists of transportation applications of associated data sets were added to Chapter 9 (Data Sets) to illustrate the value in comprehensive and consistent collection of transportation related data for performance evaluation and planning.

2.3.2 TxDOT Feedback and Focus Group Meetings

In addition to soliciting topic experts for their feedback, the research team also met with the TxDOT Project Monitoring Committee (PMC) multiple times, providing overviews of the Reference's draft contents and organization. In general, PMC members emphasized the importance of relating the Reference's contents to TxDOT activities (rather than more academic concepts that regularly come up within the economics discipline and texts such as those by Small and Verhoef [2007]). They requested more TxDOT-project-specific examples, and content reformatting to a more user-friendly (and oftentimes shorter) document. To better appreciate the TxDOT staff perspective, the team and the PMC coordinated two focus group meetings (with a total of 14 TxDOT staff) on February 29 and March 19, 2012, to discuss the application of transportation economics in routine activities at the agency. A transportation focus group expert, Tina Collier-Geiselbrecht, moderated these meetings, and her summary focus group findings are provided as Appendix A to this report.

Each focus group began with a roundtable of participants providing feedback on their current use of transportation economics in decision-making and projection evaluation and implementation. The team then presented several economic analysis methods for more feedback. This effort helped the team identify topics of greatest interest to the intended audience. The meetings revealed that, while formal economics analysis is not utilized by TxDOT personnel on a regular basis, there are many opportunities for such principles to be accommodated within existing TxDOT practices. Furthermore, the value of such a Reference was not readily apparent to a variety of employees, who are busy responding to daily work demands.

In response to feedback from the PMC and the focus group meetings, the team made several significant changes to maximize the Reference's value for TxDOT staff. First, the structure of each core chapter was significantly altered. Taking inspiration from transportation references such as the *Highway Capacity Manual* (2010), CTR's Maureen Kelly helped reformat the lengthy chapters to highlight terms, concepts, and examples, with core content summarized at the start of each chapter, focusing on key concepts. Key concepts and terms were also highlighted in the margins of the chapters in callouts for easier reader navigation. She moved more detailed concepts and their nuances to "In-Depth Look" sections at the end of each chapter, and added a key term overview to the start of each chapter. The concise primary core chapter content is easier to digest for readers who are unfamiliar with transportation economics, while the in-depth sections provide greater detail for those wanting to dig deeper into the content.

In addition to the Introduction chapter serving as a roadmap to the Reference, it also provides a list of related questions that TxDOT personnel often face at the end of each chapter's overview. This enhancement to Reference navigation helps dispel the misconception that engineers "don't use economics." Time-constrained staff members can get a strong sense of the Reference simply by reading the nine-page introduction.

To provide the Reference a more real-world feel for practitioners, TxDOT-relevant case studies and examples are inserted throughout the 307-page document, including such topics as calculating savings in delay costs from the implementation of a continuous-flow intersection,

evaluating bridge rehabilitation versus replacement, and pavement lifecycle analysis. Where Texas examples were unavailable, the team identified examples from other departments of transportation to illustrate economic tools to enhance TxDOT's current practices.

2.4 Developing Case Study Applications (Project Task 4)

The Reference's wide variety of topics often play out simultaneously in practice. They involve both quantitative and qualitative analysis for comprehensive assessment of economic impacts and related indicators. Four case study applications were developed to demonstrate the interconnectedness of economic concepts in the Reference: benefit-cost evaluation of network improvements, economic impacts of bypasses, consequences of congestion pricing, and costs of right-of-way acquisition. These case studies illustrate how various economic concepts introduced in the Reference weave together, and their understanding can enhance TxDOT planning, investments, and policymaking while highlighting the value of statistical data analysis. The case studies demonstrate the flexibility of econometric methods for mining Census data, land use information, and other agency data to quantify relationships between variables of interest. Such relationships are essential in anticipating transportation project and policy impacts.

In addition to the Reference's detailed case studies, the Case Study chapter contains an introduction to Transportation Project Impact Case Studies (T-PICS), which is a collection of case studies tracking the economic impacts of highway projects collected via the Transportation Research Board's Strategic Highway Research Program.

Chapter 3. Developing and Presenting Supplementary Slideshows (Project Task 5)

In order to most effectively introduce economic concepts and methods to various TxDOT personnel, the research team created three suites of Microsoft PowerPoint slides covering core transportation economics concepts and complementing the Reference's text. The resulting three-part workshop or seminar series is organized by topic and seeks to enable self-guided instruction (by TxDOT personnel directly) and organized presentation by TxDOT staff (to colleagues).

These slide-based modules cover Reference topics that are most relevant to the day-to-day activities of TxDOT staff. Module 1 presents key background concepts by first illuminating the economic motivation behind the Reference's creation, then covering basic land use and transportation interaction principles, and lastly demonstrating how the various transportation costs and benefits are quantified (and compared through benefit-cost analysis).

Modules 2 and 3 cover methods of economic analysis. Module 2 starts with basic project evaluation and comparison techniques, such as life-cycle analysis, multi-criteria analysis, and constrained optimization, and then presents various principles of transportation (road) pricing. Module 3 covers more complex project analysis methods, in the form of predictive models for economic impact analysis (using input-output techniques and computable general equilibrium models) and advanced statistical methods (for econometric modeling of transportation data sets). Each slideshow includes detailed notes below each slide, for presenters and those seeking further details and supporting information.

As an initial test run and to familiarize TxDOT staff members with the context of the upcoming Reference, these modules were presented to staff via in-class lecture and (simultaneous) webinar participation on August 21 and 23, 2012. For the slideshows' final version, the team incorporated the participating staff's feedback and added instructor's notes for optimal content delivery in future TxDOT in-house lectures and webinars.

Chapter 4. Conclusions

Through the many interactions with TxDOT staff during the two-year development of the project 0-6628 Transportation Economics Reference, it was evident that current TxDOT planning and operations activities regularly use transportation economics principles on an informal, and often qualitative, basis. Through these same interactions, it was evident that opportunities for practical incorporation of economic principles and practices are abundant. The resulting Reference provides the necessary information for TxDOT personnel to implement economic concepts, methods, and tools in the context of project design, operations management, policymaking, budgeting, and various other types of decision-making.

Armed with a wide variety of economic analysis and evaluation tools, agency staff can go beyond casual rules of thumb and employ formally documented processes for economic decision-making. Addressing issues ranging from appropriate charges for contractor schedule delays to optimal budget allocation across distinctive project types, the Reference speaks directly to transportation practitioners' regular needs. For large projects with significant costs closely scrutinized by the public, TxDOT personnel can feel more confident in their decision-making with a basic understanding of various economic principles. Such principles and associated tools allows anticipation of the general direction and magnitude of project impacts. The Reference's attention to transportation economics fundamentals, analysis methods, and case studies illustrates the endless opportunities for economic considerations within transportation. Its attention to real project details (a feature mirrored in the PowerPoint slides) should allow departments of transportation like TxDOT to rapidly disseminate key economic concepts and applications via formal staff-training and self-guided learning.

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Appendix A. Focus Group Write-Up to TxDOT by T. Geiselbrecht

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March 30, 2012

TECHNICAL MEMORANDUM

TO: Dr. Kara Kockelman, University of Texas
Dr. Duncan Stewart, Texas Department of Transportation (TxDOT)

FROM: Tina Geiselbrecht, Texas Transportation Institute, Mobility Management Office
Richard T. Baker, Texas Transportation Institute, Mobility Management Office

SUBJECT: TxDOT Staff Focus Groups on Transportation Economics

On February 28, 2012 and March 19, 2012 two focus groups were convened at the Texas Department of Transportation's Austin District Office. The purpose of these meetings was to discuss the application of transportation economics in transportation decision-making. The groups were conceived to add "real world" examples of how transportation economics is used by TxDOT staff on a routine basis. The February meeting was attended by eight TxDOT employees involved in planning activities (referred to in this memo as the "planning" session), while the March meeting was attended by five TxDOT employees involved in operations, maintenance, construction or overall decision-making regarding all district activities (district engineer, deputy district engineer, directors). This group is referred to in this memo as the "operations" session. Each session was facilitated by a moderator. There was also a note taker. Both the facilitator and the note taker were from the Texas Transportation Institute. There were also two experts on transportation economics from the University of Texas.

Each session began with a general discussion of transportation economics and how it is utilized in the daily jobs of the participants. Participants were asked about how they currently utilize transportation economics in decision-making. Discussion then turned to the various processes for decision-making with regard to how projects are developed and implemented. Each session concluded with a presentation by University of Texas representatives on transportation economic analysis methods where participants were asked to provide input on the various methodologies.

From the interactions of the group three primary conclusions can be drawn:

1. Transportation economics is not, for various reasons, generally utilized by TxDOT staff on a regular basis.
2. The value of transportation economics to TxDOT staff for use in decision-making processes is not readily apparent and staff is generally skeptical that the use of economics-related analysis tools would facilitate better decision-making or otherwise be of value.

3. There are, however, opportunities to incorporate transportation economics-related principles into existing practices.

Current Utilization of Transportation Economics

A general conclusion that can be drawn from these sessions is that transportation economics is not used in day-to-day planning and operations related TxDOT activities. This can be attributed to numerous factors including:

- A general lack of knowledge about transportation economics, its theories and application;
- There are numerous factors outside of economics that influence departmental decision making;
- Economics-related exercises are generally not required or are generally undertaken by third parties;
- TxDOT is generally in a "reactive" mode when it comes to project development and is not in a position to anticipate where infrastructure development will be needed.

Many of the focus group participants noted that they were not familiar with transportation economics principles and were not sure how it would be applied in their regular job activities. For example, at the outset of the planning session there were questions as to what transportation economics actually entails. Staff noted that there are numerous occasions were data that might be used in an economic analysis is generated and utilized in regular decision-making processes. However, participants were unsure if the analyses supporting these decision-making efforts were themselves economic in nature. For example, the department makes regular use of data, such as crash monetization, travel time savings, and latent demand calculations (for use in assessing the overall cost associated with expansion of infrastructure). All of this data might be utilized in a transportation economic analysis. However, it was unclear to participants the extent to which district decision-making that utilizes these data could be classified as economic in nature. It was noted that similar data is also used in traffic modeling and congestion analysis.

In the few cases where a staff member sought to utilize economics related tools, they were generally unable to locate useful resources as the data provided was often not at the local level. Another participant noted that that they had attempted to utilize various online transportation economics resources but were unsure of which ones would be the most appropriate for the situation.

It was noted repeatedly that other factors outside of economics tend to influence departmental decision-making. Participants in the planning session noted that the first and perhaps most prominent consideration in the district decision-making processes is that of funding availability. It was noted repeatedly that TxDOT has critical needs, such as maintenance, that must be addressed before other, longer term priorities. This sentiment was prevalent in both the planning and operations sections. Staff in both sessions made numerous comments regarding the difficulty in allocating funding among competing projects such that needs can be adequately met. For participants in the planning session this often means that larger, longer term projects are put off in favor of smaller, more easily implemented projects. Projects are developed at the area office level with an eye towards what is likely to be funded. Area managers are viewed as having a better perspective on their area's specific needs, and they are thus responsible for identifying candidate projects for the district to review and then approve for funding. Area engineers are aware of the funding situation and often break up larger projects into smaller components that have a greater likelihood of being funded. In the operations session, available funding was also mentioned as a deciding factor within the context of balancing needs across the system. Participants in the operations session stated that they are continually involved in a "balancing" act, wherein less effective (but cheaper) solutions to roadway maintenance and construction related issues are often adopted in lieu of more long

term (and more expensive) solutions. An example used by participants in the session was that of making repairs to FM/RM roadways within the district. The district has high levels of black clay which negatively impact pavement quality and since these facilities generally see a lot of traffic the best solution would be to utilize concrete pavement. However, this is an expensive solution and in order to maintain a consistent level of maintenance across all of the district's facilities the most practical solution is building an asphalt facility and using seal coats for repairs. This tradeoff is necessary because in most cases the department is already behind in terms of addressing infrastructure needs, inaction is not an option as that would contribute to continued deterioration, and funding is limited to implement the most desirable solutions.

It was also noted that many decisions are imposed on the district, and that not having available funding is an insufficient reason to keep these types of projects from moving forward. For example, participants in the operations session stated that traffic signal related work for intersections where there have been fatalities must be addressed and cannot be put off for lack of funding. In terms of prioritizing these types of projects staff noted that they maintain a list and when signal work is required the project goes onto this list. Projects are generally handled in the order in which they were placed on this list but certain signal projects may be advanced or bumped down the list for various reasons. However, the reasons for advancing or demoting a candidate project on this list generally have nothing to do with economic considerations and economics is not used in determining priority on the list.

In addition to the availability of funding, the desire to minimize the negative impacts of transportation projects was cited as an additional factor in decision-making. In the planning session it was noted that in practice the department seeks to "avoid, minimize, or mitigate" when it comes to addressing the potential negative impacts of a project. Projects with a significant impact, such as those that disturb archeological sites or cross historic property, require a more vigorous analysis to be approved. This can significantly increase the cost of the project. For example, a stringent 4F analysis can take four to five years to complete and significantly increase the costs of the project. As such, many design decisions are oriented around reducing the need for a higher level environmental impact analysis. For example, a project at FM 1431 was shifted to the north of that roadway in order to avoid the Leonard Wilson archaeological site, as the original plans would have required work to be done too close to the site would have triggered a higher level impact analysis. This in turn would have increased the time and cost required to complete the project. At a smaller scale, changes to project aspects like retaining and noise walls and reducing right of way are generally put in place to minimize the negative impacts and thus cost and effort associated with a project.

TxDOT staff observed that in many cases economic analyses of the type being discussed are rarely required and are thus not undertaken in a proactive manner. During the course of the planning session one of the TxDOT staff related an anecdote from a project they participated in that did utilize an economic assessment (though this participant was not a TxDOT employee at the time). They stated that the assessment was required because economic development was identified in the "purpose and need" statement of the project. Thus, a rigorous economic analysis of the project was required for approval. It was noted that these sorts of goals are typically not incorporated into TxDOT related projects and such analyses are not typically carried out.

In cases were exercises resembling an economic analysis are undertaken it is most often for larger scale projects, projects involving tolling, or projects that would otherwise receive a heightened level of public scrutiny. For these projects, the district most often considers benefits and costs and staff stated that that the district generally looks for "anything better than a 1" in terms of the ratio of benefits to costs in deciding to move forward on a specific alternative. These analyses are often utilized in making the case to the public about the merits of a particular project. For example, for work on Loop 360 the district will be conducting a series of public meetings that will feature the results of micro-simulations showing before

and after conditions on the roadway, illustrating the possible economic impact of the project, and estimating the rate of return over the next 7 to 10 years. Economic analyses are also used for larger projects such as those on facilities that appear on various lists of the most congested corridors in the state. Analyses for these types of projects generally focus on calculating things like travel time savings and fuel savings. Furthermore, these analyses are generally over a single corridor, as opposed to looking at regional impacts, and often only take into account peak periods.

With regard to TxDOT not generally being required to do economic analyses, it was also pointed out that the agency is most often in a reactionary mode; responding to development after it has occurred as opposed to anticipating it. This sentiment was expressed in both the planning and operations session. In the operations session, staff noted that "99 percent" of the time they are playing "catch-up" in that the work they are doing should have been done years ago. Staff noted that when they are working on roadways they try to keep future needs in mind, such as what areas are likely to need signals or where turn lanes might be needed, but often they are unable to address these issues due to insufficient funding and resources. In cases where work is being done on a facility the effort to bring that facility up to a certain level of service is identified and if longer term issues can be addressed then they are, but this often does not happen. Staff in the operations session also noted that it is difficult to anticipate future needs, with the Austin area F-1 track being used as an example of a major unforeseen future impact on traffic.

The absence of economic analysis in TxDOT decision-making has resulted in a situation where work of that nature is contracted out to private entities or is handled by local entities. TxDOT staffers at both sessions acknowledged that this is problematic, as they are generally not able to assess the accuracy of these analyses. However, given resource constraints it does not appear that there are any immediate remedies.

Skepticism of the Value of Transportation Economics

TxDOT staff appear unconvinced that there are substantial benefits from the utilization of transportation economics in planning and operations related activities. For example, it was noted in both sessions that district efforts to reduce the negative impacts of projects, minimize costs, and maintain consistent roadway quality across the district should be sufficient in and of itself. Some staffers did not think that the actual savings need to be quantified so long as the department can say that it is saving money. The inability to see the value in transportation economics and staff apprehension about its use can possibly be tied to several factors:

- The numbers involved are dynamic and create expectations that are static;
- Benefits and costs are not necessarily the same from person to person;
- There is a perception that not all costs and benefits can be quantified; and
- Staff feels that even if such analysis is undertaken it will not necessarily drive decision-making.

It was noted by participants in the planning session that the very presence of performance-oriented measures on a potential project creates expectations on the part of the public that might not be met once the project is completed. If a project is put forth to the public on the basis that it will provide certain travel time savings, then the public will expect those savings to be realized, even if the numbers that went into the estimate were faulty. There was a general apprehension among some staff about being held to performance metrics that they were not involved with generating and that they do not have full confidence in. This issue is exacerbated by the reliance on third parties for most economic analysis that staff lacks the expertise or experience to validate.

There was also discussion in both the operations and planning sessions about the difficulty of communicating the benefits of proposed projects to the public. In the operations session participants stated that road users who attend public hearings on proposed projects are generally the ones that will be negatively affected by the project. These individuals are not concerned with improving travel times for all users in the corridor and are more concerned about how the project affects them personally. There was also discussion in the planning session regarding the difficulty in dealing with aggregate versus individual costs and benefits for a project. For example, aggregate benefits for travel time savings resulting from a project may be substantial, but on a driver by driver basis it may not be significant. In these situations, it can become difficult to justify a large capital improvement that requires millions of dollars when aggregate travel time savings translate to only a few minutes per driver. Furthermore, individual costs and benefits are not uniform across all system stakeholders. Landowners, who may be directly involved with and affected by the proposed project, will not evaluate a project's worthiness based on travel time savings. They will likely only care about the value of their land that must be acquired by the department.

Furthermore, it was noted, that there are potential costs associated with various aspects of project development that can be difficult to quantify. For example, in situations where archeological sites are involved, such as the aforementioned Leonard Wilson site near FM 1431, the true value of the site itself is difficult to value relative to the transportation factors. Any such assessment would be perceived as comparing "apples to oranges." Furthermore, there is a substantial cost associated with public perception of transportation projects. This is an aspect that certainly affects overall cost, but it is difficult to quantify.

There was also skepticism voiced in the sessions about whether economic analyses, if undertaken by the various divisions, would actually be utilized in decision-making processes. This line of thinking was particularly evident in the operations session. In response to a statement by one of the experts about how economic analysis can be used in the property appraisal process when acquiring right-of-way, one of the participants stated that it does not matter what appraisers say the value of the property is because such decisions are ultimately made by the appraisal court. Furthermore, it was noted that the validity of economic analyses used in these situations is more often tied to the experience and reputation of the appraiser rather than the soundness of the methodologies employed.

Opportunities for Incorporating Transportation Economics

It should not be concluded from this discussion that transportation economics and economics related principles are never utilized in TxDOT planning and operations activities. However, when used, it is generally on a more informal basis and is often qualitative in nature. It was noted by TxDOT staff in the planning session that in situations where there are multiple alternatives that the designers are expected to develop a decision matrix. And while information utilized in the matrices may be economic in nature, the process by which projects are selected from the matrix is generally not based on any economic theory. In other words, they are not using an economic model. In the operations session it was noted that managers try to set parameters for designers upon project initiation through the use of concept meetings where, depending on the job, staff will: assess what needs to be done, evaluate possible strategies, and analyze what has worked well in the past. These operations exercises might utilize data that is economic in nature but cannot be called an economic exercise. Additionally, there are times when transportation economics related information might be generated and utilized but it appears to be on a smaller scale. These include:

- Savings to drivers in costs from delays were utilized in a redesigned continuous flow intersection over a 10 year period,
- Projects involving noise walls, as TxDOT must document that there is at least $20,000 in benefits per receiver on the project,

- Bridge replacement / rehabilitation assessment also generally include some type of costs benefit analysis,
- The Transportation Planning and Programming Division often takes into account future land use.

Staff also noted that there may be significant value in doing life-cycle costs analyses on different pavement types. It was also noted that economic principles might be applied in bottleneck studies. In the operation session staff stated that economic analyses would have been very beneficial in pursuing road projects through the federal stimulus such as the TIGER program. Participants stated that they did not have the time or resources available to prepare the economics related documentation required for larger, more long term projects and have been unsuccessful in receiving TIGER funding. The district did; however, receive stimulus related funding through the American Recovery and Reinvestment Act (ARRA) which required them to document construction jobs that were being created. There was interest in both sessions in utilizing these principles to examine how infrastructure development affects job creation. It was noted that these types of analyses could be particularly useful in promoting future projects.

There are opportunities for the incorporation of more economics related principles and practices in planning activities. For example, it was noted repeatedly that much of the information that might be used in an economic analysis is already used for other planning activities. Furthermore, many local and regional entities as well as real estate developers are already doing these sorts of exercises.

As noted earlier in this memo there are three general conclusions that can be drawn from the interaction with TxDOT staff and their use of transportation economics in their job duties. Based on those conclusions, the following recommendations are offered:

- *Transportation economics is not generally utilized by TxDOT staff on a regular basis.*
  Recommendation: The development of a basic primer could help in addressing basic comprehension of transportation economics. This primer would essentially be a stripped down version of the larger reference manual on transportation economics and would present information similar to what was discussed in the second half of the focus group sessions including basic transportation economics analysis methods. This primer should be developed as both a print and online resource.
- *The value of transportation economics for decision-making is not readily apparent to TxDOT staff and the staff is generally skeptical that the use of economics-related analysis tools would facilitate better decision-making.*
  Recommendation: The value of transportation economics to the planning and operations of state roadway facilities could perhaps be illustrated, either in the reference manual or the aforementioned primer, through the use of case studies. Economic theory in and of itself can come across as abstract to those not practiced in its application. By showing how other transportation professionals in similar positions have utilized transportation economics, either in every day job duties or as part of larger planning and operations related activities, the concept becomes less alien.
- *There are opportunities to incorporate transportation economics-related principles into existing practices.*
  Recommendation: Researchers should determine what activities are currently being undertaken by TxDOT staff that could incorporate elements of transportation economics. Institutional friction is likely to be high, so it is unlikely that profound changes in existing practices and processes should be expected. Rather, researchers should focus on identifying simple economic concepts that can be easily incorporated into existing practices.