Draft

Benefit/Cost Analysis for Transportation Infrastructure:
A Practitioner's Workshop

May 17, 2010
Washington, D.C.

Workshop Proceedings

August 2010

Transportation Economics Center

TEXAS TRANSPORTATION INSTITUTE

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle	5. Report Date
Benefit/Cost Analysis for Transportation Infrastructure: A Practitioner's Workshop – Proceedings	August 2010
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Katherine F. Turnbull	Report
9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Texas Transportation Institute The Texas A&M University System College Station, TX 77843-3135	11. Contract or Grant No. DTOS 59-10-D-00504
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Office of Economic and Strategic Analysis U.S. Department of Transportation 1200 New Jersey Ave, SE Washington, DC 20590	Technical
	14. Sponsoring Agency Code

15. Supplementary Notes

Carl Swerdoff, U.S. DOT, Contracting Officer Technical Representative (COTR)

16. Abstract

This report summarizes the *Benefit/Cost Analysis for Transportation Infrastructure: A Practitioner's Workshop*. The Workshop was held at the U.S. Department of Transportation (U.S. DOT) building in Washington, D.C. on May 17, 2010. This document summarizes the presentations from the Workshop. Speakers discussed the key elements of benefit/cost analyses, the differences between benefit/cost analyses and economic impact analyses, and addressed job creation and real estate investment benefits. Representatives from the Federal Transit Administration (FTA), the Federal Highway Administration (FHWA), the Federal Railroad Administration (FRA), and the Maritime Administration (MARAD) described benefit/cost analyses for the different modes. Speakers also discussed measuring the benefits of the U.S. DOT's strategic goals – safety, livability, state of good repair, economic competiveness, and environmental sustainability – and measuring costs.

17. Key Words	18. Distribution Statement
Benefit/Cost Analyses, BCA, Economic Impact Analysis	No restrictions. This document is available to the public through NTIS: National Technical Information Service 5285 Port Royal Road Springfield, Virginia 22161

19. Security Classif.(of this report)	20. Security Classif.(of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	72	

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

Table of Contents

LIST OF TABLES

LIST OF FIGURES

Welcome

Jack Wells
U.S. Department of Transportation

Good morning. It is pleasure to welcome you to this Practitioner's Workshop on Benefit/Cost Analysis for Transportation Infrastructure. The motivation for this workshop resulted from our experience with the TIGER I grant program, which was part of the Recovery Act. The U.S. Department of Transportation (U.S. DOT) was responsible for administering the TIGER I grants. Typically, funding for transportation projects flows from the federal government to the states and to other government units, which then decide which projects to fund. The TIGER I grants were unusual in that the decisions on which projects to fund were to be made by the U.S. DOT, because the program was intended to focus on transportation projects of national significance, while at the same time stimulating the economy.

There has been growing concern on the part of the transportation community and on Capitol Hill that there are national transportation problems that are not receiving adequate attention from decision makers at the state level. Senator Patty Murray, Congressman James Oberstar, and others have focused on the need to address national transportation infrastructure issues. The $1.5 billion TIGER I program in the Recovery Act was an attempt to begin addressing these needs. The President's proposal for a National Infrastructure Bank, which has now become the National Infrastructure Innovation and Finance Fund, is also designed to address the transportation infrastructure issues that are important from a national perspective.

One of the requirements of the TIGER I grant program, which was a high priority of the White House, was that applicants provide a benefit/cost analysis (BCA) on proposed projects. This guideline reflected in part the Executive Order adopted in 1994 during the Clinton Administration that directed discretionary infrastructure programs to require such an analysis. Including a BCA was part of the application requirement for both the TIGER I and the High-Speed Rail grant programs.

In reviewing the approximately 1,400 applications for the TIGER I grant program, we found that many applicants had difficulty understanding the basic elements of a BCA and had problems completing a BCA. While some applications contained very well-done BCAs, others misunderstood the BCA requirement and the elements of a BCA. Based on this experience and the BCA requirement in the TIGER II grant program funded through the FY 2010 Appropriations Act, we decided that outreach was needed on explaining BCA and the expectations of including a BCA in the application.

Preliminary guidance on the TIGER II program was issued a few weeks ago. It contains more detailed information on conducting a BCA. We have received comments on the preliminary guidance and we will be responding to those comments in the final guidance, which should be issued in the next few weeks.

Andrew Metrick from the White House was not able to join us this morning. If he were here, I think he would have stressed that the President places a high emphasis on ensuring that the decision-making process for infrastructure grants is based on the best quality analysis available. Our task is to share information on the appropriate analysis techniques.

We have an excellent group of speakers for the workshop today. Daniel Graham from the Imperial College in London will provide an overview of the BCA concept and how it is applied to infrastructure decisions in Great Britain. Glen Weisbrod from the Economic Development Research Group will discuss the differences between BCA and economic impact analysis. We found in the TIGER I applications that there was a lot of confusion between BCA and economic impact analysis. Glen will highlight the differences between the two analysis techniques and describe the appropriate use of each. David Lewis will discuss addressing job creation and real estate investment benefits in a BCA, which was also an issue with many of the TIGER I applicants.

The final session this morning is a panel of speakers from the different modal agencies discussing the challenges of applying BCA in the context of the various modes. Mary Lynn Tischer from the Federal Highway Administration (FHWA), Richard Steinmann from the Federal Transit Administration (FTA), Ronald Hynes from the Federal Railroad Administration (FRA), and Eric Gabler from the Maritime Administration (MARAD) will also highlight some of their experiences with the TIGER I applications.

Speakers in the afternoon will discuss the categories of benefits that correspond to the U.S. DOT's five strategic goals. Darren Timothy, FHWA, will discuss BCA and safety, Todd Litman, Victoria Transportation Policy Institute will describe BCA and livable communities, and Rabinder Bains, FHWA, will highlight BCA and the state of good repair. After a short break, Kenneth Button, George Mason University, will discuss BCA and economic competitiveness, and Charles Griffiths, U.S. Environmental Protection Agency (EPA) will summarize BCA and environmental sustainability. Arlee Reno from Cambridge Systematics, Inc. will discuss how to measure costs. Katie Turnbull from our new Transportation Economics Center at the Texas Transportation Institute (TTI) will summarize the key themes for the day.

The workshop is a joint effort of the Office of Economic and Strategic Analysis at the U.S. DOT and the new Transportation Economics Center at TTI, which is a part of the Texas A&M University System. The purpose of the Center, which was established earlier this year, is to mobilize the resources of the transportation economics community around the country and around the world to assist the U.S. DOT in addressing complex issues in transportation economics. Conducting workshops, sharing best practices, facilitating discussions on critical issues, and undertaking research are all objectives of the Center. This workshop represents the first major project of the Center. We appreciate the work of the Center in helping to organize the workshop and we look forward to working with the Center and all of you on future workshops and other activities.

Introduction and Overview

Cost-Benefit Analysis: Introduction and Overview of the United Kingdom Approach

Daniel Graham, Imperial College, London

Thank you, Jack. It is pleasure to participate in this workshop. The title of my presentation is Cost-Benefit Analysis: Introduction and Overview of the United Kingdom (U.K.) Approach. We use the term Cost/Benefit Analysis (CBA) in the U.K., rather than BCA, which is used in the U.S. Both terms refer to the same process and analysis.

CBA is a complex topic, which is challenging to cover in a short time period. My comments focus on six key aspects of CBA. I will begin by reviewing the principles guiding CBA and discuss the U.K. CBA process. I will summarize the key components and assumptions of CBA calculations, the limitations of CBA, and on-going developments, including the assessment of Wider Economic Impacts (WEIs). I have been actively involved in research related to WEIs for the past five years. The interest in WEIs results from the concern that traditional CBAs do not capture all the benefits. I will conclude with a few examples of the use of CBAs from the U.K.

The U.K. Treasury defines CBA as "...an analysis which quantifies in monetary terms as many of the costs and benefits of a proposal as feasible, including items for which the market does not provide a satisfactory measure of economic value." (U.K. Treasury, *Appraisal and Evaluation in Central Government*, 2003). This definition focuses on the key principles or characteristics of CBA as it is applied in the U.K.

First, CBA is comprehensive in scope. It incorporates a wide range of considerations. In addition to financial impacts, CBA also considers safety, environmental, travel time, and other impacts. CBA does not cover all of the factors that may be considered in the transportation decision-making process, however. For example, CBA does not consider political factors.

Second, CBA has a social perspective. CBA is based on the view that a net increase in welfare is a good thing, even if some groups within society lose out. This perspective is called the Hicks-Kaldor assertion. CBA is not focused on finding the most financially viable project. Rather, CBA is focused on finding the project that delivers the most benefits to society as a whole. CBA examines the costs and the benefits that are accrued to different groups in society. Some groups may win and some groups may lose. CBA focuses on the net effect of a project.

Third, CBA focuses on monetary terms. The CBA approach qualifies all costs and benefits financially. Cost and benefits are monetized for all factors. Finally, CBA focuses on individual valuation. Benefits and costs are measured by how individuals value them, not social planners or analysts.

Figure 1 illustrates the basic elements of the CBA process. I have highlighted five elements or steps in this process. The first step is identifying the specification of the project options, which may focus on improving travel times, improving safety, and supporting economic growth. Defining alternative projects that can meet these specifications is part of this first step. It is important that the definition of alternative projects is broad. For example, many city authorities in the U.K. are interested in the light-rail transit (LRT) system. Some people would argue that the benefits for gated bus systems would be as great or greater than LRT and the costs

would be lower. As a result, both LRT and gated bus systems should be considered as alternatives.

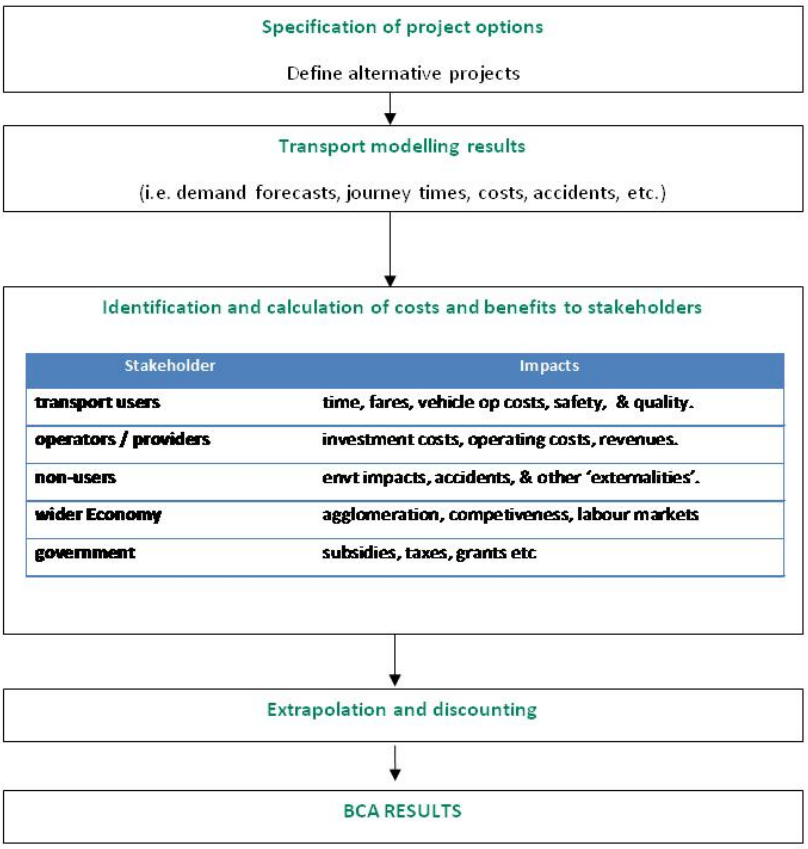


Figure 1. CBA Process Outline.

Modeling the changes to the transportation system resulting from the proposed projects represents the second step. The transportation analyst can model changes in journey time, transportation costs, accidents, and other variables.

Step three focuses on identifying and calculating the costs and benefits to stakeholders from the transportation project. Figure 1 presents examples of possible impacts on different stakeholders. The benefits and costs will be very project specific. Possible impacts on users include changes in travel times, vehicle operating costs, transit fares, safety, and reliability. Impacts on operators and providers may include changes in investment costs, operating costs, and revenues. Possible impacts on non-users include environmental, crashes, and other externalities. Potential impacts on the wider economy may include agglomeration, competiveness, and labor markets. Subsidies, taxes, and grants represent possible governmental impacts. The benefits to all user groups are monetized.

The fourth step in the process is extrapolating and discounting the costs and benefits over the life of the project. The costs and benefits are examined over the life of the project. The final step is to calculate the CBA results, which typically include summary statistics.

I will discuss how we measure costs and benefits. I will focus on the estimation of user benefits because they are typically the largest component in a CBA. They are also useful in explaining the principles of willingness to pay (WTP) and consumer surplus (CS).

The three key concepts from the theory of demand associated with CBA in the U.K. are generalized cost (GC), WTP, and CS. You may be familiar with the concept of GC. When we think of the demand for goods, we think of demand in terms of price. When price rises, demand falls and when demand increases prices fall. With transportation goods however, we use generalized costs rather than price. The GC concept realizes travelers consider both monetary and non-monetary costs for travel by different modes.

GC recognizes users travelling from *i* to *j* by mode *m* face both monetary and non-monetary costs. The time cost associated with a mode is important and GC includes this inconvenience cost. Following is the GC equation.

$$GC = price + time\ cost + vehicle\ operating\ costs + other\ charges$$

WTP is also an important concept in CBA. Each user has a maximum amount they are willing to pay to make the trip. If WTP is greater than or equal to GC, the trip is made. WTP varies by user. Economists use WTP as a measure of the gross benefits an individual derives from a trip because it represents the maximum amount an individual will exchange to make a trip. An individual has to spend money to make a trip, which is money that the individual cannot spend on other things. CS represents the net benefit to an individual. The CS is the difference between the actual price or GC of the trip and the consumers' WTP.

Figure 2 illustrates a demand function. The vertical axis is GC and the horizontal axis is quantity demand. In a transportation example, GC could be dollars per trip with quantity demand represented by the number of trips. A CBA considers the demand curve from a slightly different perspective. The demand curve also illustrates WTP, which is high on the left side of the graph and low on the right side.

Figure 3 illustrates consumer surplus, which is the shaded area A. At the generalized cost, which is constant for the trip, some people will make the trip because they have a high WTP. Their high WTP is higher than the GC, so they still receive an end benefit. The area A represents the net benefit or CS.

Imagine that Figure 3 represents the GC before a change in the transportation system is made. A transportation improvement is then implemented, which changes the GC by reducing travel times. To the consumer, the GC of making the trip has fallen. As a result, CS has expanded. As shown in Figure 4, CS has expanded to include area B and area C. Consumers already making the trip, represented by area A, are now making them at a lower GC and their net gain is represented by area B. New users are also attracted to the system because the GC has fallen. Their CS is represented by area C.

Figure 5 illustrates the change in CS, which is the measure of user benefits used in CBA. The measure of user benefits in area B plus area C shows the net change in user benefits resulting from the transportation project.

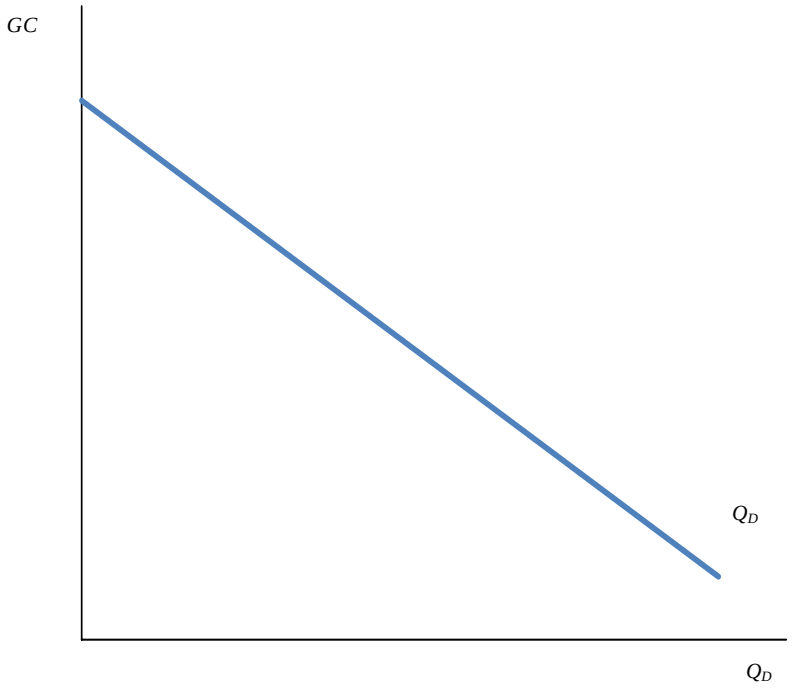


Figure 2. Calculation of User Benefits – Demand Function.

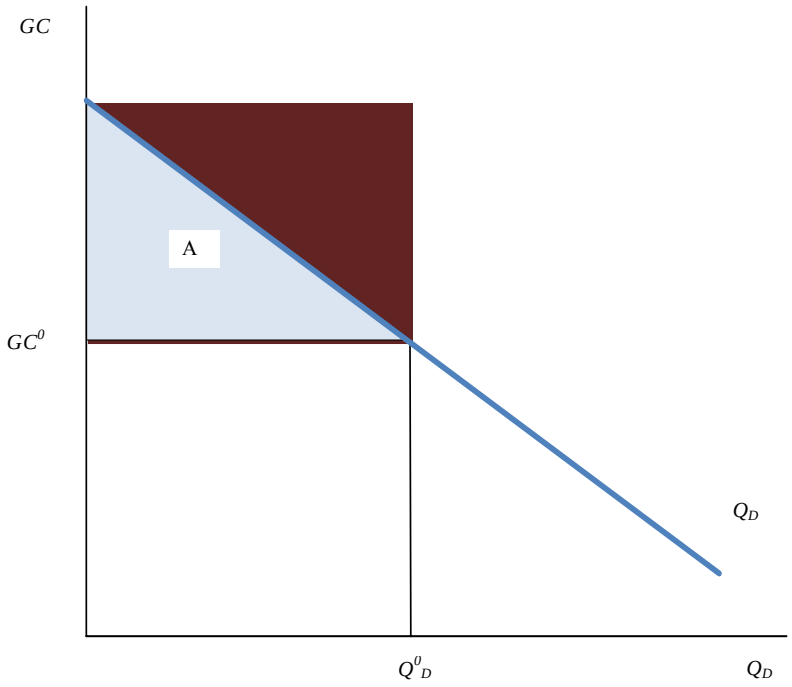


Figure 3. Calculation of User Benefits – Consumer Surplus.

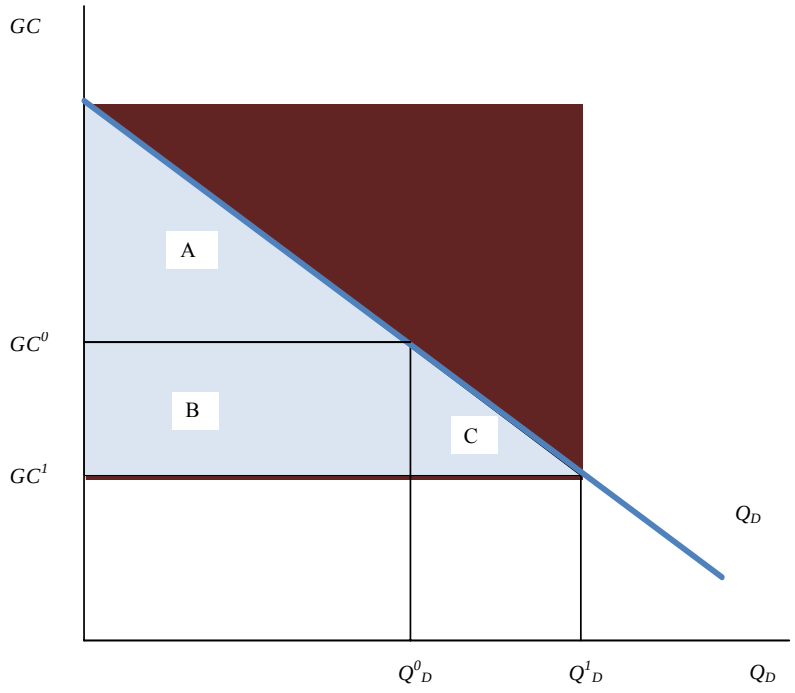


Figure 4. Calculation of User Benefits – New Consumer Surplus.

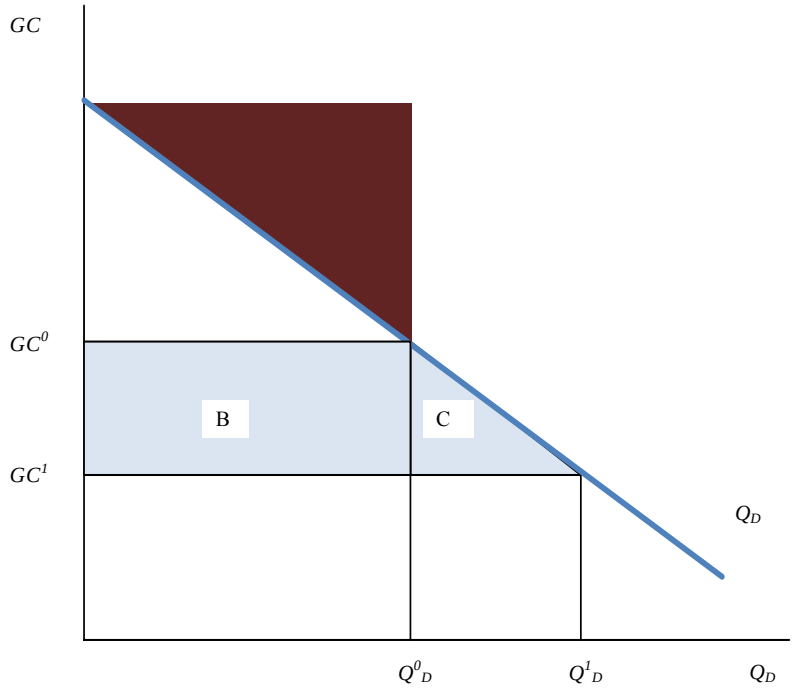


Figure 5. Calculation of User Benefits – Change in Consumer Surplus.

The practical calculation of user benefits is straight forward. The CBA calculations require estimates of demand under the do-minimum and do-something scenarios and estimates of GC under the do-minimum and do-nothing scenarios. The do-minimum is the base scenario before the transportation project is built. It is not the do-nothing alternative because some repair will have to be made to maintain the facility.

Assuming a linear demand curve, the rule of a half can be used to approximate user benefits using the following equation. Separate calculations are made for travel time, vehicle operating costs, and user charges using the rule of a half. Safety is dealt with differently. The rule of a half is not used with safety benefits, which are examined by predicting the change in safety and assigning values for different types of crashes.

$$\Delta CS \approx \frac{1}{2}\left(Q_D^1 + Q_D^0\right)\cdot\left(GC^0 - GC^1\right)$$

One issue with CBA is the monetization of non-monetary elements. Monetary values are not available for project impacts that are not traded in markets. Safety is not something that you can buy and sell. Similarly, travel time is not actually traded in the market. These elements are typically inferred from implicit or surrogate markets using WTP approaches. For example, the amount people are WTP to generate a benefit or avoid a cost can be identified through revealed preference or state preference methods.

For example, environmental externalities could be valued by examining land value differentials based on the distance from a source of noise, the opportunity cost of production contraction to reduce pollution, and the opportunity cost of relocating a national habitat. Examples of values of time include the value of working time inferred from wages, such as from the labor market, and the value of non-work time estimated statistically by examining trade-offs between time and money, such as the WTP approach.

The U.K. values of time in 2002 prices and values provide an example of estimating the value of time for different purposes. For automobiles the value per £ per hour per occupant by purpose was working – £21.86, commuting – £4.17, and other – £3.68.

Extrapolation and discounting represent the next steps in the CBA process. Extrapolation is the prediction of impacts over the lifetime of the project. It focuses on how benefits and cost change over time. It is specific to the project being considered. After we know how the impacts will change, we need to calculate them in a manner that makes sense in today's values. Discounting principles are used to accomplish this objective.

Discounting principles consider that costs (C) and benefits (B) in year t could be funded by investing a smaller amount today, Present Value (PV), with regular reinvestment of annual yield. We sum the value today of all discounted costs and benefits.

The CBA results provide summary measures. The Net Present Value (NPV) and the Benefit Cost Ratio (BCR) are the two commonly used summary measures. NPV is the present value of a project's benefits (PVB) minus the present value of its costs (PVC). The BCR is the PVB/PVC. These summary measures are used in the decision-making process. For example, a decision might be made to proceed with a project if its NPV is positive. In another example, if alternative projects are being considered, the project with the highest NPV may be selected. In a

further example, a marginal acceptable BCR may be defined and projects are accepted or rejected accordingly.

There are limitations with CBAs. The first limitation is monetization. CBA necessarily involves value judgments. These value judgments can be contentious and can prejudice the decision maker toward certain project impacts. Second, CBA is sensitive to the input values, especially demand and cost forecasts. Additionally, the calculation of NPV and BCR can be highly sensitive to the choice of a discount rate.

The potential for additionality of benefits is another limitation. The WTP approach creates scope for double counting benefits, particularly regarding "transfers." Double counting of benefits should not occur. Analysts need to ensure that benefits are counted only once. Another limitation is that the magnitude of time savings may be very small with many projects. While time savings are typically the largest component in a CBA, small time savings may have little productive value. A final limitation relates to coverage. Consumer surplus theory assumes perfect markets and the absence of market failure. Violations of these assumptions create unaccounted benefits and costs. One of the main areas of research is examining the WEI of projects to address all the economic benefits realized from transportation projects.

The focus of recent research is on agglomeration benefits. Agglomeration economies are positive externalities derived from the spatial concentration of economic activity. Agglomeration economies provide sources of knowledge and technology sharing, labor market pooling, specialization, and efficient input-output sharing. Clearly, transportation and the generalized costs of travel affect agglomeration. Transportation costs in part determine economic densities and accessibility. Transportation constraints can inhibit agglomeration economies. New transportation investments change the density or concentration of activity, including labor, and accessibility to firms. Agglomeration is an externality or market imperfection, and as such, it is not captured in a standard CBA based on WTP.

As an example, the U.K. Department for Transport (DfT) assessed agglomeration benefits for CrossRail, a major mainline rail infrastructure project for Central London. Using an agglomeration elasticity of approximately 0.10 they found a 25 percent addition to the conventional user benefits.

The Eddington Study in the U.K. provides an example of applying CBA to the impact of transportation on economic growth and productivity. It examined CBAs for different types of projects, including improving the urban transportation networks, improving access to international gateways, and improving interurban corridors. Some of the interurban corridors had very large BCRs because they were addressing major pinch points or bottlenecks in the transportation system. The BCRs also increased when the average economic returns from government expenditures with Gross Domestic Product (GDP) impacts were added. The results indicate that the economic returns of smaller projects are as significant as many relatively large projects.

References

Mackie, P., D. Graham, and J. Laird. *The Direct and Wider Impacts of Transport Projects – A Review*, 2010.

Mackie, P., and J. Nelthorp. *Cost-Benefit Analysis in Transport*, 2001.

Mallard, G., and S. Glaister. *Transport Economics*, 2008.

Layard, R., and S. Glaister. *Cost-Benefit Analysis*, 1994.

Eddington, R. *The Eddington Transport Study*, DfT: London, 2006.

Mackie, P. and J. Preston. "Twenty-One Sources of Error and Bias in Transport Project Appraisal", in *Transport Policy*, 5, 1-7, 1998.

Questions

When you examine the costs and benefits, do you also examine the lost opportunity to undertake other projects?

Dan Graham – CBAs are conducted for each individual project. Comparisons of BCRs across projects can be made, but CBA does not include a calculation of lost opportunity costs.

One of the examples you presented had agglomeration benefits of 25 percent. That seems high. How was it applied in the CBA?

Dan Graham – The agglomeration benefits in the CrossRail example were high because the project is located in Central London. I think, as a general rule of thumb, appraisals that have calculated WEIs show agglomeration benefits in the range of 10-to-20 percent of the total project benefits. However, the extent to which transportation investments really do generate tangible agglomeration benefits is actually quite controversial and is the subject of ongoing research. My own opinion is that these benefits have probably been vastly overstated in the appraisals conducted in the U.K. to date.

How do you select the discount rate? Is it government wide or just for transportation? In the coordination of the economic analysis and the financial considerations, some people at the state level would say you cannot buy concrete with CS or time savings. As result, projects are selected based on their financial viability rather than their overall economic benefits.

Dan Graham – On the first question – in the U.K. there are official discount rates for use with transportation projects. On the second question – CBA is typically a subset in the factors considered in the decision-making process. CBA provides information that may or may not be used in the decision-making process.

How do you consider individuals with different income levels? Individuals with higher incomes may be more likely to pay for some benefits than individuals with lower incomes.

Dan Graham – Currently, the same measures for travel time and other benefits are used regardless of income levels and regions.

Jack Wells – At the U.S. DOT, we do consider different values of time for different modes of transportation. Since air travel is faster, there is a higher value of time for aviation. We do not allow for different values of time within a mode. We also do not allow for different values of time for different locations within the U.S. We also use the same value of statistical life (YSL) for all individuals regardless of income levels. We will discuss this topic more this afternoon.

Being Clear About Benefit/Cost Analysis and Economic Impact Analysis
Glen Weisbrod
Economic Development Research Group

Thank you, Jack. As there are a number of government economic stimulus programs underway, it is natural to talk about the impacts of these programs on the economy. A clear understanding of the differences in the use and the measures associated with BCA and economic impact analysis (EIA) is thus important. That is the focus of my comments.

I will highlight four major topics in my presentations. First, I will describe the benefit perspectives for decision support and the different parties involved in conducting BCA and EIA. Second, I will define EIA and BCA and note the differences and the need for clarity. Third, I will discuss matching measures to social issues, and separating efficiency, equity, and other objectives. I will conclude by describing double counting and under-counting and highlight methods to avoid both.

Figure 6 illustrates five different stakeholder groups in transportation infrastructure investments. These stakeholders include facility operators, users, external parties, government and financiers, and the public and the economy. As Figure 6 shows, different analysis methods are associated with the different stakeholder groups. Operators are interested in financial information, including project costs and revenues, and the economic viability of a facility. Fiscal impact analyses are conducted for governments and financiers, who are interested in fee revenues and expenditures for bonding or taxation. Determining the benefits to users and external parties is also important for assessing fiscal impacts. Ensuring consistency between travel modeling and evaluating benefits is particularly important. There can be situations where the modeling process predicts significant usage of a facility or service, but major benefits accrue to parties other than the direct users. There can also be situations where there are substantial benefits to users, but the model does not predict much change in facility use. EIAs can thus be useful to distinguish such impacts affecting the broader public or the economy.

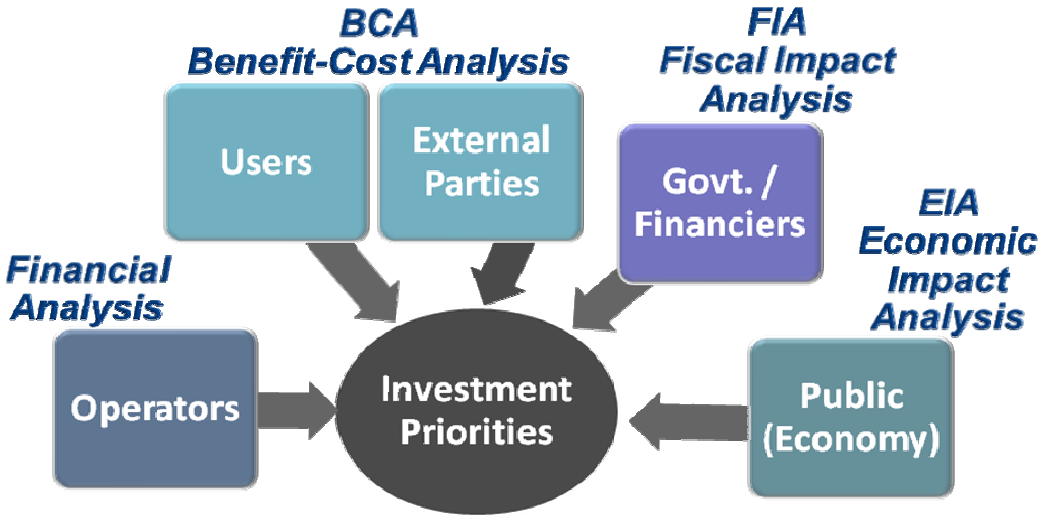


Figure 6. Stakeholder Groups and Different Analysis Measures.

There are also impacts on non-users and external parties, including the environment and social values. We can examine the benefits and costs to users or the benefits and costs from a broader society viewpoint. It is important to define the terms used by different groups. Economists consider the term "social benefits" to encompass all benefits. Transportation planners and environmental planners working in the contact of environmental impact studies sometimes place narrower meanings on the terms "social" and "environmental" factors.

From an economic development perspective, there is also an interest in job creation and helping distressed communities, which are the primary motivations of the economic stimulus programs. A different set of questions and different measures are needed to address the economic development impacts of projects. Further complicating the situation, some economists use a very narrow definition of benefits that include only benefits to users or else users plus environmental benefits. Others define benefits to also include non-user benefits such as business productivity gains. Finally, there is also a body of literature that suggests all of the measurement elements in Figure 7 are a part of a broader BCA family. So it is possible to define BCA to encompass benefits and costs to all of society, or else to focus only on specific groups or areas.

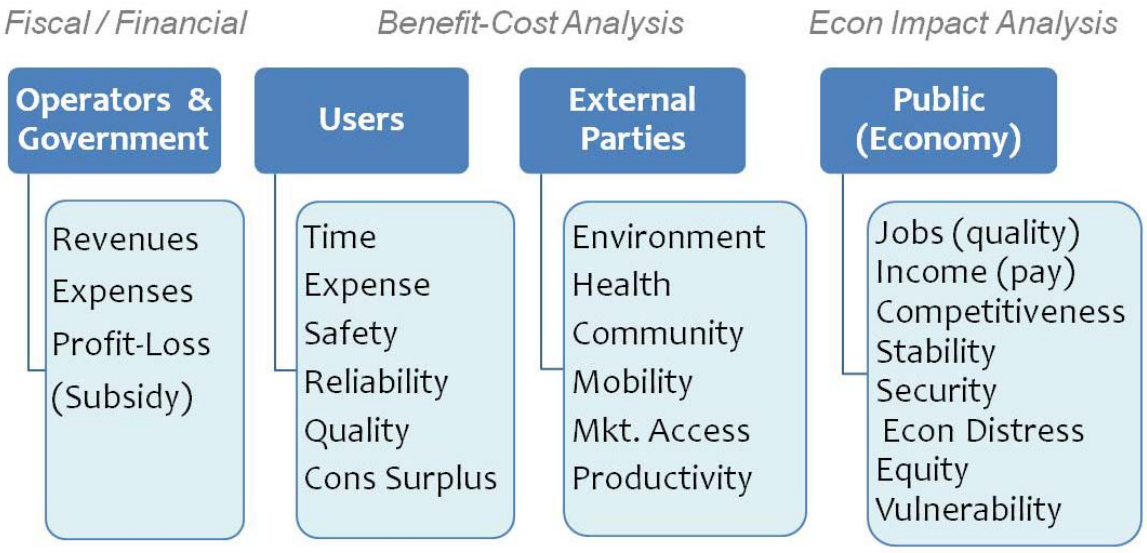


Figure 7. Measurement Elements.

When financial analysis for operators and fiscal or economic impacts to government are being considered, the focus is on the flow of money. When overall benefits and costs are being analyzed, the focus expands to include both money and WTP, which is not a flow of money. Another distinction that can be made relates to spatial coverage. Government fiscal impacts or public economic impacts focus on a specific government jurisdiction. Broader BCAs may focus on society as a whole. There are similarities and differences among the various types of analyses, which may cause confusion and result in the use of wrong analysis techniques and measures.

From the point of view of operators and government agencies, the key monetary measures include revenues, expenses, and profits/losses or subsidies. In contrast, travel time, travel costs, and safety are important BCA measures for users, especially with highway projects. In some cases, reliability, quality, and consumer surplus measures may be included. If the user benefit is being measured by taking the volume or the number of people affected multiplied by the savings in time, money, and crashes, then consumer surplus may be defined to mean the incremental consumer benefit over and above the direct user benefit that is already being measured. This also applies when there is induced demand for a facility.

Measures used in BCA may include benefits to external parties or the broader society, including effects on the environment, health, mobility, market access, and productivity. Identifying monetary values for these types of effects is more difficult because transportation is typically thought of as public good and is usually not priced. Stated preference surveys represent one method used to assign monetary values to these types of measures.

Assessing the economic development aspects of economic stimulus programs requires a different set of measures. Economic developers want good, well paying, quality jobs and jobs with upward opportunities. In terms of competiveness, they are interested in industries with major growth opportunities, not just saving money. Economic developers want businesses that are not subject to seasonal layoffs and that are secure from layoffs due to risk, distributional equity, or threshold factors. It is possible to identify a WTP value for these items, which can be included in a BCA though that is seldom done. Instead, public agencies typically prefer to itemize these items separately, using a balanced scorecard or multi-criteria analysis. A scoring or weighted system can be used with these techniques.

It is important to remember that not all of these approaches need to be used. Focus on the specific question you need to answer, the specific object, and what is being measured. Match the correct method to what you are trying to measure. I would offer the following definitions, which are similar to those presented by Dan Graham. BCA compares alternative actions based on the relative costs incurred and the benefits gained. It includes the valuation of benefit and cost streams in monetary terms over time and is expressed as a discounted present value. EIA analyzes the effect of a program or project on the economy of a given area. It is viewed in terms of changes in the economy over time and expressed as the change in economic activity (output), income (value added or wages) and associated jobs. The composition of affected industries and occupations can be important with EIAs.

Table 1 presents the potential for benefits to different groups associated with various measures. As noted previously, traveler benefits focus on time savings, operating cost savings, and crash cost savings. Potential economic development impacts include more factors, including shipper and receiver productivity gains, market access and scale productivity gains, income from business location shifts, and income from suppliers and consumer spending. An accounting framework can be developed and used to track the different measures for use in the analysis.

A typical BCA would examine the traveler, full user, and societal benefits associated with travel-time savings, vehicle operating expense savings, and crash cost savings. A full user BCA would include the value of consumer surplus and productivity gains for shippers and receivers. A BCA considering societal benefits would include market access and productivity gains, environmental and health benefits, and community, quality of life, and mobility benefits.

Table 1. Benefit Coverage Differences.

	Traveler Benefit	Full User Benefit	Societal Benefit	Economic Development Impact
$ Passenger Time Savings - personal travel	Yes	Yes	Yes	--
$ Passenger Time Savings - business travel	Yes	Yes	Yes	Yes
$ Travel Vehicle Operating Expense Savings	Yes	Yes	Yes	Yes
$ Travel Safety (Accident) Cost Savings	Yes	Yes	Yes	Yes
$ Value of Consumer Surplus	--	Yes	Yes	--
$ Shipper/Receiver Productivity Gain *(Reliability, Connectivity, Logistics, Supply Chain)*	--	Yes	Yes	Yes
$ Market Access & Scale Productivity Gain *(Labor Mkt, Delivery Mkt Scale & Agglomeration)*	--	--	Yes	Yes
$ Value of Environmental & Health Benefits	--	--	Yes	--
$ Value of Community, Quality of Life, Mobility	--	--	Yes	--
$ Income from Business Location Shifts	--	--	--	Yes
$ Income from Suppliers, Consumer Spending	--	--	--	Yes

The factors included in an EIA are both broader and narrower than the factors in a BCA. Some factors are deleted and some factors are added. Factors not considered in an EIA include personal travel-time savings, consumer surplus, the value of environmental and health benefits, and the value of community, quality of life, and mobility benefits. These items are not considered because an EIA focuses on the flow of money and income.

Factors typically added in an EIA include income from business location shifts and income from suppliers and consumer spending. For instance, some programs are focused on increasing spending in highly distressed areas. Attracting additional tourists to these areas helps address this stress, and would be included in an EIA. From a national perspective, the tourists may just be relocating from another area, so it would not be included in a national EIA.

Table 2 presents the differences in cost coverage for BCAs and short- and long-term EIAs. The cost of property acquisition for a project is important in a BCA, but is not considered in an EIA. Project construction costs are included in a BCA and short-term EIA, while operations and maintenance costs are included in a BCA and a long-term EIA. Fees, tolls, and taxes may be considered in both a short-term and a long-term EIA.

Table 2. Cost Coverage Differences.

	Benefit Cost Analysis	Short-term Econ Impact (*temporary jobs*)	Long-term Econ Impact (*permanent jobs*)
$ Cost of Property Acquisition	cost	--	--
$ Cost of Project Construction	cost	Yes	--
$ Cost of Project O & M	cost	--	Yes
Fees, Tolls, Taxes	--	*	*
Depends on jurisdiction (may be inflow of $ to area or outflow of $ from area)			

It is important to match the measures used to relevant social issues. A BCA is designed to ensure efficient use of scarce resources, minimize costs among alternatives that achieve needs, and maximize performance results for given available funding. On the other hand, an EIA is designed to stimulate and grow jobs and income where they are most needed, such as distressed areas, and attract quality, well-paying, stable, and secure job-growth industries where income can rise over time. As such, an EIA focuses on economic vitality, sustainability, and competitiveness. EIAs are also designed to ensure equity and assistance for vulnerable populations, and reduce vulnerability risk from dependence on foreign suppliers.

There are different interpretations of terms between a BCA, which presents an economist's view, and an EIA, which takes an economic developer's view. In a BCA, "competiveness" most commonly means reducing expenses or saving money. In an EIA, the term "competitiveness" may focus on improving the capability to operate businesses, thus retaining and attracting economic activity (jobs and income) in the area. In a BCA, the term "sustainability" is most commonly defined in terms of environmental quality, specifically reducing air pollution. An EIA on the other hand, might focus on improving economic sustainability – the ability of a specific type of economic activity to remain financially viable in the area. In a BCA, the term "livability" might be defined in terms of enhancing accessibility and mobility as reflected in increased property values, while in an EIA, it might focus on improving the attraction of the area as a place to work and live. Different concepts of "productivity" factors are also used. Productivity factors in a BCA are often viewed as a market imperfection that affects generalized costs and are addressed separately. In an EIA, the focus is on factors differentially affecting income and cost competitiveness for different industries.

It is also important to be clear about causal relationships and the potential danger of adding multiple outcomes. As illustrated in Figure 8, investments in the transportation system result in transportation changes, which have a value and lead to broader effects on the economy.

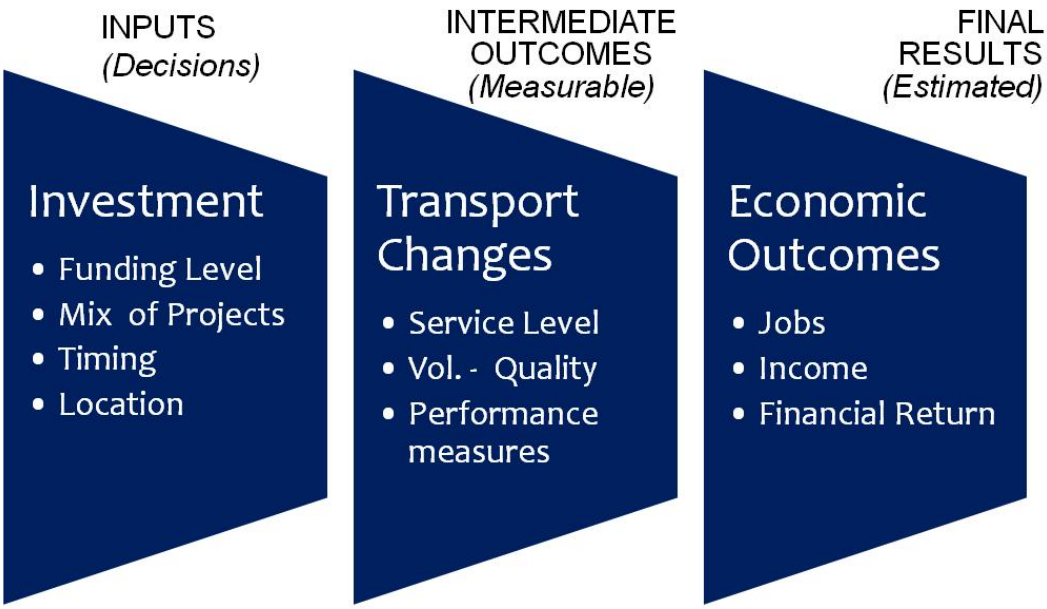


Figure 8. Causal Relationships.

The danger of double counting occurs any time you span more than one of these columns. For that reason, you should not add multiple measures that reflect the same underlying changes. You should not add travel impact measures, such as value of time savings, and economic measures, such as income generated. You should not add multiple economic measures, such as business output, value added, or GRP together with income or wages. You should not add property value appreciation, such as wealth measures, with income measures. You also should not count transfer payments, such as fees and property sales, which do not grow the economy.

Figure 9 presents an example of a BCA spreadsheet from a TREDIS model of transportation economic benefits and costs. It itemizes separately factors such as vehicle operating costs, travel time and reliability costs, safety costs, additional consumer surplus, logistic benefits, market access, and social and environmental costs. These calculations are made for each mode, and then added together to provide the total present value of benefits, the total present value of costs, the NPV, and the benefit/cost ratio. It clearly highlights the elements included in the BCA. In comparison, an EIA would typically present data on output value added jobs by industry, value added jobs by year, and value added jobs by sectors.

Present Value of Benefit Stream ($m 2008 Const dollars)								
	(A) Traveler Benefits ($)		(B) Traveler Benefits (non-$)			(C)	(D)	(E)
Mode	Vehicle Operating Costs	Time & Reliability Costs	Value of Personal Time & Reliability	Safety Cost	Additional Consumer Surplus	Shipper/ Logistics Benefit ($)	Market Access Productivity ($)	Social/ Environ. (non-$)
Pass Car - OTC	10.8	217.7	0	0.9	0.1	0	--	--
Pass Car - Commute	46.2	445.4	445.4	1.6	0.6	0	--	--
Pass Car - Pers/Rec	23.1	0	399.4	0.4	0.4	0	--	--
Truck - Freight	36	265.4	0	2.7	0	195.3	--	--
Project Totals	**116.1**	**928.5**	**844.9**	**5.6**	**1.1**	**195.3**	**75.9**	**5.7**

Benefit Measure	Benefit Definition	Present Value of Benefit Stream	Present Value of Cost Stream	Net Present Value (Benefits - Costs)	Benefit/Cost Ratio
Traveler Benefit	**A+B**	1,896	626	1,270	3.03
Full User Benefit	**A+B+C**	2,092	626	1,466	3.34
Total Societal Benefit	**A+B+C+D+E**	2,173	626	1,547	3.47

Figure 9. Example of Benefit-Cost Analysis Spreadsheet.

The following references may be of use in conducting an EIA. The California Department of Transportation (Caltrans) website also provides a good summary of the differences between BCA and EIA. Thank you.

Using Empirical Information to Measure the Economic Impact of Highway Investments. Federal Highway Administration, 2001. http://www.edrgroup.com/hwy-impact.html.

Guide to Quantifying the Economic Impacts of Federal Investments in Large-Scale Freight Transportation Projects. U.S. Department of Transportation. OST, 2006, http://www.dot.gov/freight/guide061018/index.htm.

Transportation Benefit-Cost Analysis Guide. Transportation Research Board. 2010, http://bca.transportationeconomics.org/.

Questions

How do you address the potential movement of benefits from one area to another?

Jack Wells – We take a national perspective on the transfer of benefits from one part of the country to the other. We received some grant applications, for example from ports that noted commerce would be transferred from another port in the country. While that might benefit the specific port, it is not a benefit from the standpoint of the U.S. as a whole.

Given the recent oil spill, how do you factor in catastrophes and the impact on the environment, tourism, jobs, and the economy?

Glen Weisbrod – It is possible to add a risk adjusted measure on the benefit in a BCA. David Lewis, who will be speaking next, has done extensive research in risk analysis. There are methods using Monte Carlo simulation and other techniques to obtain an expected value of risk.

If the consequences are dramatic, that should be factored into the BCA. Some events may be so catastrophic that they cannot be factored into a BCA, but that is just one of the limitations of the process.

If new jobs are created due to regulatory concurrence and there are reduced delays due to the project, it is double counting to count both?

Glen Weisbrod – In general, BCA assumes other factors are in place to enable the transportation project to move forward and the resulting benefits to be realized.

Employment, Productivity, and Real Estate Value in Benefit/Cost Analysis
David Lewis
HDR

Thank you, Jack. My comments focus on the effects of transportation projects on job creation, employment, and real estate values, which are often not considered in BCA. I will highlight a few of the foundational issues of BCA. Dan Graham and Glen Weisbrod have addressed many of these issues in their presentations. I will then discuss the effects of transportation investments on labor markets and real estate value.

As other speakers have noted, BCA measures the creation or erosion of real economic value. Value denotes welfare or quality of life. The transfers of value between people, places, or firms should not be counted as costs or benefits. Benefits and costs may manifest themselves in multiple effects, including travel time savings, property values, shipping costs, and the price of consumer goods. The effects of these factors in a BCA should be counted only once, not multiple times even though they may appear in different manifestations.

The effects of transportation investments on labor markets can be examined in four different ways – short-term jobs due to project construction, long-term jobs due to project operations and maintenance, productivity benefits from business reorganization, and other productivity effects due to agglomeration and diversion to more productive modes.

Productivity growth in the economy is a principal means of generating real growth in incomes. It is one thing to grow jobs, but it is another thing to grow real incomes and the standard of living. The source of real standard of living improvements in our economy is productivity growth. Examining how jobs manifest themselves in productivity growth is thus important.

When examining short-term jobs due to project construction, the labor used for construction is in general a cost, not a benefit. At a local level, these short-term jobs, are of course, a good thing. From a BCA standpoint, however, using labor for a specific project makes it unavailable for other value-creating opportunities. If wages reflect the real opportunity cost of labor, then short-term jobs are a wash from the worker's point of view. Labor is a project cost.

The opportunity cost of labor considers what workers would be doing in the absence of the specific project. Workers could be employed in a similar activity, employed at a lower-productivity job, unemployed but engaged in productive activity, or unemployed at leisure. The opportunity costs of labor declines as we move down this list.

When unemployment is low, is can safely be assumed that project workers will likely be working in similar jobs at competitive wage rates, and that wage rates are close to the real opportunity cost of labor. When unemployment is high, however, project workers may be

otherwise un-employed or under-employed. In this situation, because wages tend to be rigid, the prevailing wage rate can exceed the real opportunity cost of labor. This situation means that the project's labor cost measured at market wages is too high to reflect the true opportunity cost of that labor. Wages may be discounted or reduced, rather than taken at market level, to better reflect the true cost of labor. This method is called shadow pricing.

The difficulty in shadow pricing is determining how much to reduce or discount wages. Shadow pricing is currently used more in Europe than the U.S. The European Commission Guidelines on BCA considers the shadow wage to be inversely correlated to the level of unemployment. In the example below, the shadow wage is equal to the market wage times 1 minus the unemployment rate.

$$Shadow\ Wage = Market\ Wage\ (1\text{-}u)$$

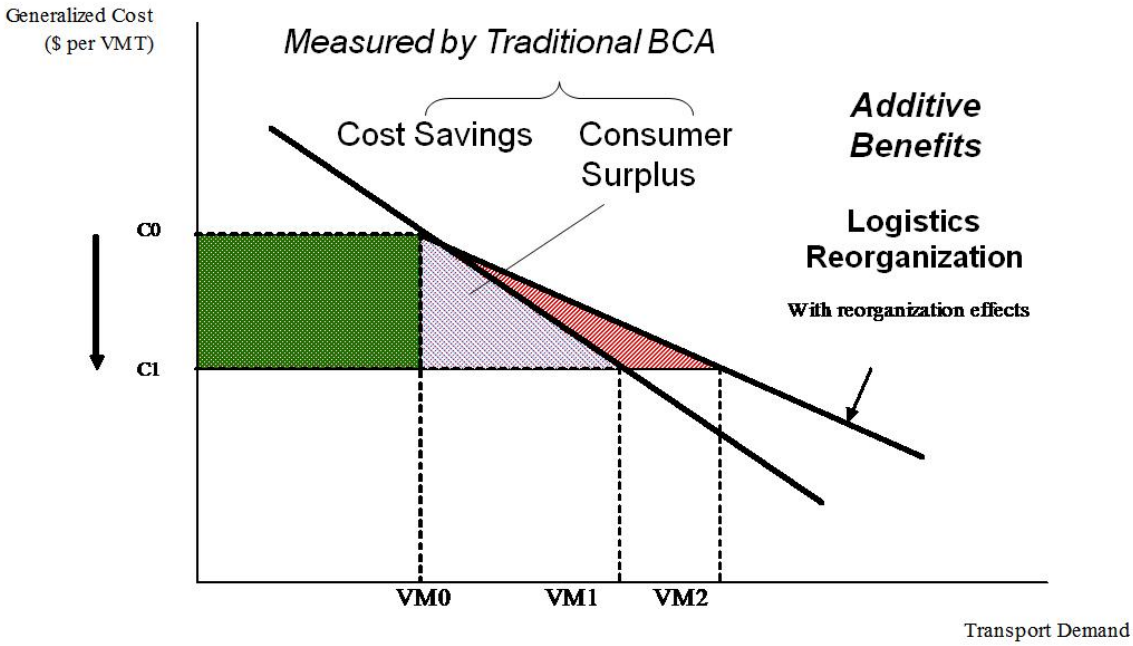
For example, if regional unemployment is 12 percent for unskilled workers, the conversion factor for that category of labor is equal to 1 minus the unemployment rate or 0.88. More information on this approach is available in the European Commission, Directorate General Regional Policy, Guide to Cost-Benefit Analysis of Investment Projects, July 2008.

The same general principles apply for long-term jobs due to project operations and maintenance. The labor used for operations and maintenance is a cost when employing people for a specific project makes them unavailable for other value-creating opportunities. Shadow pricing is more difficult in this situation due to uncertainty in market conditions in the medium and long-term. The European Commission Guidelines do acknowledge that long-term structural unemployment exists in some areas and that shadow pricing might be appropriate.

Productivity benefits from business reorganization represent the third way to examine the possible effects of transportation investments on labor markets. Firms can take advantage of improved transportation services by reorganizing logistics. More reliable transportation, especially more reliable networks, permit just-in-time delivery, thus reducing inventories. Firms may substitute transportation for warehousing and inventory. Shippers can serve a larger market area with existing facilities at lower costs. Lower transportation costs allow reduced prices and increased output and employment.

The benefits of improved freight transportation can have cascading benefits. First-order benefits focus on cost reductions on current freight miles, reduced transit times, and increased reliability. Second-order benefits result from firms improving logistics and serving larger markets, with increases in output and freight miles. Third-order benefits focus on the development and production of improved products and new products.

Figure 10 illustrates the reorganization effects in relation to the traditional benefits – as presented in a recent FHWA report. It shows the traditional demand curve, which Dan Graham presented. In addition to the cost savings and consumer surplus discussed previously, it shows the additional benefits resulting from logistics reorganization and a "new" (long run) demand curve, which pivots out from the existing curve. Research conducted for FHWA indicates the benefits from logistics reorganization can add 7-to-10 percent to the traditional BCA. To conform with TIGER II guidelines, however, analysts cannot simply apply such a mark-up. Close scrutiny and analysis of the applicants' local situation must demonstrate strong potential for logistics reorganization as a result of the project.



U.S. Department of Transportation, Federal Highway Administration, *Freight Transportation, Improvements and the Economy*

Figure 10. Reorganization Effect on the Traditional Demand Curve.

Dan Graham also presented an excellent analysis of agglomeration benefits, in addition to total user benefits. He showed the impact of allowing for agglomeration benefits in a BCA of the CrossRail project in London. These agglomeration benefits are over and above business time savings, commuting time savings, and leisure time savings. Agglomeration benefits include the benefits of businesses co-locating due to the new facility and other related factors.

Similar to employment, real estate investment is not, in itself, an economic benefit from a BCA perspective. Real estate investments are important from many other points of view, but not from a BCA point of view. Development consumes scarce resources and the benefits of development to the community are balanced by the costs to the developer.

However, some real estate impacts may manifest themselves as true welfare effects that should be included in BCA. We are learning about these types of benefits and how to apply them in BCA. Projects can create additional economic value through the provision of better access, reduced travel time, amenities, option value, and densification and agglomeration. The location becomes more attractive to investors and buyers, driving up the price of land and property. This "price premium" reflects real value, but may be accounted for in travel time and cost savings. Part of the increase in value, however, may be more than the capitalized transportation benefit, due to option value, amenity value, and densification and agglomeration value.

While great care should be taken to avoid double counting, recent evidence indicates that part of the increase in land value may be more than just the capitalized value of the transportation and accessibility benefits. It may include option value accrued by non-users of the transportation facility. An example of option value could be the higher cost people are willing to

pay for a condominium in a transit-oriented development (TOD) because of the possibility of using transit should they need it, rather than those who already use transit. Another example is the benefit from having more businesses and shops within walking distance due to the higher densities in TODs. The challenge is to tease the extra value, the non-capitalized value, out of this property price premium.

A hedonic price function is one approach to identifying the increase in property value due to transit. A hedonic price function is an econometric methodology that describes how the quantity and quality of a property's characteristics determine its price in a particular marketplace. The following equation shows the Hedonic price function that was used to estimate the impact of transit and highway improvements on home values around the Pleasant Hill Bay Area Rapid Transit (BART) Station in San Francisco.

$$HomeVal=\alpha + \beta_1 Dist\_to\_Bart + \beta_2 Dist\_to\_Hwy + \beta_3 HomeAge + \beta_4 HomeSize + error$$

- Distance to BART - walking distance to BART station
- Distance to Highway - Distance to highway interchange
- Home Age - home age in years
- Home Size - home size in square feet

Interpretation of the regression results with a linear specification indicates a number of impacts. The results suggest that BART access was worth a premium of $15.78 more for each foot a home was located closer to the station. The analysis also indicated that some consumers pay the premium to live near the station regardless of transit use. The results seem to indicate that the premium is too large to represent capitalized user benefits alone.

A recent paper by Cevero and Duncan provides information on the percentage increase in value for residential and commercial properties associated with highway and transit projects, including different transit modes. This paper may be of use in examining benefits for proposed projects.

It is important to remember that evidence is varied and is not consistently available by transportation and transit mode. Real estate premiums will include capitalization of travel benefits, which are often accounted for elsewhere in a BCA. As a result, the extent of double counting with property value effects is uncertain. Note as well that the TIGER II guidelines are very clear about the uncertainty with respect to inter- and intra-regional effects. Finally, it is important to remember that information from Hedonic studies may not truly reflect your local project conditions.

A procedure for estimating benefits from property value premiums has been developed by applying premiums derived from Hedonic price studies. The procedure begins by identifying premiums through the selection of similar existing systems with Hedonic study data. A benefits transfer analysis is conducted next to adjust the data to fit the local situation. This step includes adjusting premiums based on forecast ridership, population, and conditions supporting development. The adjusted premiums are applied to existing and forecast residential and commercial facilities. The premium is accounted for only once as a single increase in value obtained over time. If the property value of homes close to a BART station increases by 5 percent that does not mean it increases by 5 percent per year. The total present value of benefits

realized over time is 5 percent. This point is reinforced in the TIGER II guidelines. The benefit may be amortized over time, but its full effect is counted only once. Finally, the benefit estimate is adjusted to account for double-counting of travel benefits, regional transfer, and sensitivity analysis.

The property value premium approach can be further explained using an extension to an existing LRT system as an example. Assume a metropolitan area has a population of 2.2 million and the current transit system carries 105,000 weekly unlinked trips. The new alignment, which will serve a major regional commercial center and residential areas, is projected to carry 60,000 weekly trips in 2020.

The similar systems identified are the San Diego Trolley LRT North Line and East Line, which serve similar residential and commercial mixes, and the Los Angeles LRT. The observed premium data for these similar systems include commercial premiums ranging from 1.10 percent to 71.9 percent, residential premiums ranging from 4.2 percent to 17.3 percent, and weekly ridership/population ratios of 3.46 percent and 3.54 percent.

The forecast premiums for the new extension are developed by evaluating ridership and population statistics relative to the comparison cities and evaluating development supporting conditions based on stakeholder assessments. The premiums are applied by area to the existing building stock. There is no forecast of development available for this study. The premiums are assumed to be generated once during the project lifecycle, but experienced over time. In the example, homes in one of the areas increased in value by 9 percent taken in 30 increments over time.

The benefit is reduced to account for capitalized travel benefit, assuming 25 percent to 75 percent of the benefit is the capitalization of travel benefits accounted for elsewhere. Finally, it is important to test the sensitivity to real estate premium are part of the process.

The following references provide additional information on the topics covered in the presentation.

Banister, David, Transport Studies Unit. *Quantification of the Non-Transport Benefits Resulting From Rail Investment.* Working Paper No. 1029, Transport Studies Unit, Oxford University Centre for the Environment, October 2007.

Gillen, David and David Levinson. *Assessing the Benefits and Costs of ITS, Making the Business Case for ITS Investment*. Kluwer Academic Publishers, 2004.

Lewis, David, Hickling Corporation, Silver Spring, Maryland. *Primer on Transportation Productivity and Economic Development*. *NCHRP Report 342.* Transportation Research Board, National Research Council, Washington, D.C., September 1991.

Lewis, David and Fred Laurence Williams. *Policy and Planning as Public Choice, Mass Transit in the United States*, Ashgate, 2000.

European Commission, Directorate General Regional Policy. *Guide to Cost-Benefit Analysis of Investment Projects, Structural Funds, Cohesion Fund and Instrument for Pre-Accession.* 2008.

Small, Kenneth, Robert Noland, Xuehao Chu, and David Lewis, HLB Decision Economics Inc., Silver Spring, MD. *Valuation of Travel –Time Savings and Predictability in Congested Conditions for Highway User-Cost Estimation. NCHRP Report 431.* National Academy Press, 1999.

U.S. Department of Transportation, Federal Highway Administration. *Freight Transportation, Improvements and the Economy*.

Questions

One might infer from the last part of your presentation that a transit or transportation system with lots of stations or interchanges would have more local benefits than one with stations or interchanges farther apart. More stations and interchanges may benefit local travelers but degrade travel times for longer distance trips, which may be of interest from a national perspective.

David Lewis – As I read the TIGER II guidelines for BCA, projects are desired that create true increases in economic efficiencies. Related to your example, the introduction of local area development potential at the expense of travel time should come out as a wash in the analysis. As you increase the number of stops and travel time increases between origins and destinations, the generalized cost of travel will be higher and user benefits will be lower. There may be some increase in development benefits as a result of more stations, but these benefits will not be enough to counteract the lower user benefits. From my experience, user benefits typically represents between 50-to-75 percent of the total value of a transportation project. It would be unusual for the economic development benefits to be large enough to offset the loss in user benefit.

Jack Wells – To supplement David's response, the reason benefits are provided in dollar values is to allow you to add them together. A dollar's worth of one type of benefit is the same as a dollar's worth of another type of benefit. We do not give greater value to one type of benefit over another. If you thought a certain type of benefit had an intrinsic value that was greater than the value assigned by the BCA, you could assign it some type of special premium when you assign it a dollar value. After you have assigned a dollar value, however, a dollar's worth of one benefit is the same as a dollar's worth of another benefit.

A comment was made earlier that real estate values would not be counted as a benefit of a project. Is it possible that real estate values actually represent the monetization of some things that are hard to monetorize, such as the amenities of living near a transit station or a farmer's market? These items may be as important as travel-time savings, and real estate investments might serve as a proxy for the real value an individual may gain from a transit investment.

Jack Wells – I think the point David was trying to make in his presentation was that the increase in real estate value has two components. One component is the cost of investment by real estate investors, while the other is the underlying increase in the value of the undeveloped land due to its becoming more productive as a result of the transportation improvement. For example, if you have a piece of land that is worth $20 million and you have a $40 million investment by a developer in that property, that $40 million investment is a cost to the economy because that cost is paid for by the real estate investors. If the value of that real estate parcel increases by $50 million, then $10 million is attributed to the increase in the productivity of that land, while $40 million is attributed to the investment by the outside real estate investor. The

$10 million increase in the value that was not directly accounted for by the outside real estate investor would be counted as part of the project benefits.

Panel on Challenges of Applying Benefit/Cost Analysis: A Modal Perspective

Federal Transit Administration
Rich Steinman

Thank you, Jack. I appreciate the opportunity to participate in this session. I will describe some of the challenges we face at the FTA in conducting BCA, using the New Starts Program as an example. We have a long history of assessing benefits and costs with this program.

FTA issued a policy statement in the mid-1980s, which first defined cost effectiveness. Guidelines developed in 1976 required that projects funded through the New Starts Program be cost effective. The cost per new rider was established as the basis for assessing the cost effectiveness of projects in 1984.

Project costs were examined in detail using this approach. The costs associated with different project elements were well documented and validated. Risk assessments and other analyses were conducted to provide detailed capital costs for a project. Grantees were also asked to analyze the incremental project operating costs. As a result of these requirements, we have a good understanding of the capital costs involved in the New Starts Program. FTA also has a good record of delivering projects close to the cost estimates over the past 10 years.

On the other hand, as the discussion this morning pointed out, analyzing the benefits of New Starts projects is more difficult. Initially, using new riders seemed to be a good surrogate for many of the benefits from New Starts projects. Many, but not all, benefits result from attracting new riders to the new transit investment. In 1989, FTA tried to establish a threshold value for the cost per new rider as an eligibility test for a New Starts investment. Congress directed that the single threshold of cost per new rider not be used, however.

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 added several other benefits to be evaluated in the New Starts Program. These benefits included environmental benefits, mobility improvements, and operating efficiencies. It became clear that examining a wider range of potential benefits was important. In 1997, FTA added examining land use benefits to the criteria for the New Starts Program.

In 2000, all of these benefits were modified into a regulation, which also included a broader definition of the cost effectiveness measure by examining the transportation system benefits that were outlined by other speakers this morning. The experience with applying these benefits represents another challenge. While it is easy to define mobility benefits for transit projects, it is not easy to estimate the value of many of these benefits.

Additionally, there are issues with the travel demand forecasting models used in many areas to estimate the transportation system user benefits. We have been able to obtain better transit user benefit outputs from these models over the past five years through better quality control. The definition of transportation system user benefits includes highway benefits as well. A problem has arisen in trying to accurately measure the highway benefits from the transit New Starts projects. We have not been able to successfully obtain good estimates of the congestion-related impacts resulting from changes in mode from the local travel forecasts. We have found it difficult to evaluate the highway user benefits from transit projects.

The Transportation Efficiency Act for the 21st Century (TEA-21) added requirements for considering economic development benefits. We have had a difficult time over the past few years trying to assess the economic development and land use benefits from transit projects. Impacts that have been indentified include changes in land use, changes in land development patterns, and changes in densities. How these changes relate to specific economic development benefits or measures is difficult to determine.

Environmental benefits are easier to measure, but still difficult to monetize. The travel forecasts can be used to estimate reductions in vehicle miles traveled (VMT) and reductions in emissions. It is more difficult to turn these estimates into improvements in air quality, and even more difficult to estimate the value of those changes. While environmental impacts can be measured, placing a dollar value on them is not easy.

The need to include numerous benefits in the New Starts Program has been reinforced over the past several years. In 2005, FTA again established a threshold for cost effectiveness. Congress ultimately prohibited FTA from finalizing the cost effectiveness rule and imposing it on the evaluation process. Recently, FTA has moved toward a broader threshold, which focuses on a range of efficiency measures, rather than a single cost effectiveness calculation. A Notice of Proposed Rulemaking on this approach is being developed. This Notice will seek comments on a variety of topics, including broadening the measure of effectiveness, appropriate methods to measure environmental and economic development benefits, and the overall evaluation process. This approach is moving toward more of a BCA. We want to ensure that we do not make bad decisions based upon an incomplete BCA. We want to count the benefits that matter. If appropriate benefits cannot be measured, we want to ensure they are accounted for in some way in the decision-making process. Thank you.

Federal Highway Administration
Mary Lynn Tischer

I appreciate the opportunity to participate in this session and to provide a perspective from FHWA on BCA. There are many examples of using economic impact analyses and BCA in the highway area.

BCA in highway programs provides a method to assess, and to monetize as far as possible, the benefits of projects and programs in comparison to their costs. As other speakers have noted, BCA differs from economic impact analyses, which estimates the impacts of investments on market economic indicators. Conducting BCA for highway projects focuses on travel time and vehicle operating costs. In some cases, crash costs and pollution costs are also incorporated into BCA.

The exact BCA approach depends on the policy questions being addressed. For example, BCA is used in evaluating programs, evaluating projects, conducting pavement and bridge management programs, developing safety programs, and relating systemic strategies with investment levels, such as the Condition and Performance Report. There is also a link between BCA and performance management.

Information on the various BCA tools available for use with highway projects is available on the FHWA website at http://www.fhwa.dot.gov/planning/toolbox/costbenefit_forecasting.htm and on the California Department of Transportation (Caltrans) website at http://www.dot.ca.gov/hq/tpp/offices/ote/benefit_cost/index.html. The report, "User Benefits

Analysis for Highways," prepared by the American Association of State Highway and Transportation Officials (AASHTO) should be available soon. There are also proprietary tools developed by consulting firms. The Transportation Research Board (TRB) Transportation Economics Committee is developing a website to highlight BCA applications.

At FHWA, we use the Highway Economic Requirements System (HERS) model, which includes BCA, to evaluate investment levels and their impact on the highway system. HERS is used to prepare the biennial Condition and Performance Report to Congress. The Highway Economic Requirements System–State Version (HER-ST) modal is additionally available for use by state departments of transportation that performs similar functions. The HERS-ST modal has been used by a number of state departments of transportation to evaluate the impacts of investment levels on the highway systems, to determine needs, to establish performance objectives, to comply with Governmental Accounting Standards Board Statement 34 (GASB 34), to perform scenario analyses, and to analyze truck traffic diversion.

There are a few examples of postprocessors for network models that are used with BCA. These postprocessors perform benefit-cost calculations using outputs from regional travel demand models. For example, one of the TIGER 1 applicants used travel model estimates, such as speed, as input into a BCA model to determine the benefits for a highway project.

Traditionally, network models have focused on travel time as a measure of performance. BCA estimation capabilities are beginning to be incorporated into some network models used by states and MPOs. Examples of this approach include the California Statewide Interregional Integrated Model, which is under development, and models used to evaluate toll roads in Austin, Texas and Oslo, Norway.

Some sketch modeling tools, such as the Surface Transportation Efficiency Analysis Model (STEAM) allow users to draw on estimates from other areas. Sketch models are useful where network effects are less important, such as with rural projects.

The challenges we face with all of our analytical capabilities are becoming more evident because of the policy issues and questions that we are being asked to address. Examples of these issues include pricing and high-occupancy toll (HOT) lanes, greenhouse gas emissions, public/private partnerships, and mainlining intelligent transportation systems (ITS). Additional issues relate to new rail starts and other transit projects, the interaction of land use and transportation, and commercial vehicles and freight movement.

Traditional travel demand models are awkward for modeling pricing, HOT lanes, and tolls, especially time-variant tolls. New-generation models will better represent time-of-day shifts, traveler heterogeneity, traffic dynamics, and land use impacts. The 2008 Condition and Performance Report produced an interesting estimate of comprehensive congestion pricing on the Federal Aid Highway System. One approach is to consider pricing as a component of the base case and project alternatives.

There are a number of challenges with estimating greenhouse gas emissions. We do not have a good understanding of how emissions vary with vehicle speed and roadway conditions and geometry. Recent evidence for conventional vehicle technologies is lacking. Even less is known about new technologies, such as electric vehicles, which are becoming more common. A current National Cooperative Highway Research Program (NCHRP) project (01-45) will recommend models consistent with current vehicle technology for estimating fuel consumption

and other vehicle operating costs. In addition, assessing the economic impacts of greenhouse gas emissions is somewhat controversial. There are also uncertainties about the timing and the long-term impacts of projects to better coordinate transportation and land use.

Public/private partnerships and investments in ITS represent other challenges. Public/private partnerships significantly alter the nature and allocation of project risks. The costing of risk has been an ongoing challenge in BCA, and public/private partnerships make it even more problematic. ITS positively impacts travel reliability, but raises questions on differentiating reliability from travel time.

Multimodalism represents still another challenge. The differences in service characteristics and service quality between modes remain a challenge for BCA, especially with modes new to a region, such as LRT or commuter rail. The demand for express bus service is an important factor in BCA for high-occupancy toll (HOT) lanes.

Data remains an ongoing challenge. There is an assumption in conducting BCAs that all relevant benefits can be measures, but "soft" factors are difficult to quantify. Issues may also arise in estimating costs for projects. Planning level cost estimates, which are developed prior to project design and years before construction, may not portray a realistic picture. The availability of accurate and relevant data is an ongoing concern. Data are often more likely to be available for infrastructure-oriented projects.

In addition to BCA, other approaches are available, especially for examining "soft" factors. Examples of these approaches include cost-effectiveness models, least-cost planning approaches, multi-criteria goal achievement, and analytical hierarchical analysis. Least-cost planning is used in Washington State.

The relationship of BCA to performance management is important and needs additional consideration and research. Setting targets can be used to determine the relationship between investment levels and performance measures. The Condition and Performance Report to Congress represents an example of this approach. Tradeoff analyses explore the performance implications of various allocation scenarios. The Southeastern Michigan Council of Governments (SEMCOG) analyzed four scenarios based on different projects and programs. Resource allocation represents the link between planning and programming, including examining other ways to achieve the objectives. Finally, monitoring and reporting provide a feedback loop.

The use of BCA and other methods provide objective information for the decision-making process. The information from BCAs leads to better informed investment decisions. BCAs and other approaches identify relationships between investment levels and performance outcomes, and assist in developing target levels or performance measures that could be achieved at particular funding levels. Finally, they enable tradeoffs between investments, which achieve various levels of performance.

Federal Railroad Administration
Ronald Hynes

Thank you for the invitation to participate in this panel. My comments focus on the use of BCA within the FRA. Historically, the FRA has focused primarily on safety and the safe operation of railroads in the U.S. The FRA has always supported AMTRAK, but through TIGER I and AARA, FRA funded rail projects around the country.

We have examined the approaches used by the other modal administrations and learned from their experiences. For example, we reviewed the FTA New Starts Program, which Rich Steinman described. We are also studying the experience with the TIGER I applications. Further, we are examining the benefit from different projects around the country.

A new rail cooperation research program is being initiated, modeled after the NCHRP. This program will help address rail research needs, including those associated with conducting BCA for rail projects. There are numerous areas of needed research associated with examining the benefits and costs of different types of rail projects.

Some of the TIGER I freight rail project applications did a good job of addressing BCA. State department of transportation or other agency goals were presented. How the rail project supported those goals was also presented. Some applications examined both short-term benefits and long-term benefits, which would be realized at full build out. For example, the Crescent Corridor project estimated saving 14 lives a year at full build out due to reductions in crashes. Reductions in VMT were also estimated.

Examining the safety benefits of different types of rail projects is one area where additional research is needed. We want to ensure the safe operation of the rail system, as well as the interaction of rail with other modes. Safety benefits are realized from rail/highway grade crossing projects, as well as improvements with rail links at ports.

Some of the TIGER I projects with good BCAs were intermodal facilities. The impacts on land use, the environment, the overall state of good repair, and removing trips from congested roadways were examined in these applications. The impact on the full transportation corridor, especially between mega-regions, was considered in some applications. Comparing the shipping costs and reliability of alternative modes in a corridor is important. We also learned a lot from participating with other modal agencies in the review of the TIGER I applications. We need to consider the broader perspective of possible impacts, including those associated with safety, air quality, water quality, and economic competiveness.

My office recently completed a national rail plan, which projects needs to 2035. Population growth, economic growth, and other factors were all examined. The costs and benefits associated with building and not building rail, highway, air, water, and intermodal facilities needs to be examined. Both freight and high-speed passenger rail facilities need to be considered. We look forward to continuing to work with the other modal agencies on these and other issues. Thank you.

Maritime Administration
Eric Gabler

I appreciate the opportunity to participate in this session and to provide a perspective from the MARAD and our clients, which include ports and maritime service providers around the country. Conducting social BCA is new to most ports. While ports have traditionally been publicly owned, many of the facilities and operations at ports are privately owned and managed. As a result, most ports are very adept at conducting financial analyses, including cash flow analyses of port costs and revenues received from private operators. Many ports and marine service providers do not have comparable experience in estimating public benefits.

When federal investments in port infrastructure are being considered, however, assessing the public benefits from these projects is important. In other words, we want to know what the

public is receiving in return for the public grant funding. These public benefits, which might include reductions in landside traffic congestion or criteria pollutants, are additional to the shipper and carrier benefits captured by the port in its financial analysis of port revenues. Conducting social BCA for the first time can be intimidating.

The first step for maritime groups new to conducting a BCA is to focus on the ability of current infrastructure at the port or facility to meet future public and private demands. This assessment will define the need for a project. Ports are facing numerous issues that make projecting future needs difficult, particularly with regard to the ships and freight volumes the port must be sized to serve. Examples of these issues include the widening of the Panama Canal, greater use of post-Panamax ships, the ability of the Suez Canal to accommodate ships up to 250,000 dead weight tons, changing global markets, and future exchange rates (which influence the balance of exports and imports). These issues will affect different ports in different ways. Changing logistic practices will also impact ports in different ways.

Economies of size are very important when considering port projects. A new crane to load post-Panamax ships is not cost effective for loading smaller ships. Ensuring that projects are correctly sized to meet anticipated traffic flow is important, but, as noted, estimating future traffic volumes is not easy given all the uncertainties and changing conditions. Many ports are examining expansion plans in anticipation of post-Panamax demand, but it is possible that very large container ships will make only one or two port calls per trip. Projecting how ports will fit into this new world is difficult.

It is also important to define the project's base case (i.e., the no-build scenario). Explaining how the port would operate without the proposed project or investment is the purpose of the base case. Once the base case is defined, different options to address the identified need for the new investment should also be presented. These alternative options must then be analyzed to determine the incremental benefits and costs they create relative to the base case. Examining more than one investment alternative, ranging from small-scale to large-scale improvements is recommended.

As noted, determining the public benefits from proposed projects can represent a major challenge to ports. Rather than thinking only about what they can charge clients for the use of a specific facility, ports need to focus on the benefits to the public and other stakeholders from the proposed projects. For example, an improvement in an access road to a port might reduce traffic congestion, reduce emissions, and improve safety for drivers and residents of surrounding communities. These types of benefits represent public benefits. They are typically not associated with the revenues ports obtain from clients and users. These public benefits are different from the private benefits realized by port clients and users. They are typically not associated with the revenue ports obtain from clients and users.

As other speakers have noted, there are often differences between local benefits and national benefits. Businesses relocating to your port from another port due to a project may be good for your port, but enabling such a shift is not a national benefit. It is therefore important to focus on the benefits to the local area that also benefit the country as a whole. The TIGER II guidelines provide directions on these items. It is also important to focus on the benefits related to your specific project, rather than the economy at large. For example, many projects will not have agglomeration benefits discussed earlier today.

Additionally, it is beneficial to be transparent in presenting your information. Document how you estimated the benefits, what methodology you used, and what values you applied. Even if the reviewers do not agree with all the assumptions or values you use, they will at least understand how you estimated the benefits. Providing explicit information on your assumptions, and why you used these assumptions will serve you well.

In summary, present your case in a straight-forward manner. Do not let conducting a BCA become paralyzing. Convey the basics of your project, why it is needed, and the anticipated benefits. Summarize the benefits and how you valued them. Thank you.

Questions

As other speakers have noted, the impact on shipping patterns from the widening of the Panama Canal is not known. It has been suggested that port projects justified by shifts in traffic from one port to another may have been rated lower than other projects, especially those on the East Coast that were taking traffic from the West Coast ports. We know the traffic patterns will change and that traffic will shift from West Coast ports to East Coast ports. The real question is who will get the increased traffic and will it be U.S. ports or ports in other countries?

Eric Gabler – Economies of size are very important in the port industry and will continue to be important in the post-Panamax era. Identifying the anticipated or the potential shifts in shipping resulting from the widening of the Panama Canal is appropriate. You can also identify cost reductions and increased benefits to the nation from a project. For example, purchasing a post-Panamax container crane and making improvements to a pier may reduce shipping costs by a certain amount to all potential users, which is a benefit to the nation.

Jack Wells – It is also important to distinguish between responding to a shift that will take place due to the widening of the Panama Canal (and how your port is accommodating that shift) from a shift that is occurring only because of an investment at a port. As Eric noted, you really want to focus on how a port investment will reduce the cost to shippers and consumers.

How do you capture the benefits to highways and congestion relief from transit projects? Second, some argue that there is a difference in the value of time associated with the characteristics of the various modes. For example, the value of time may be different on commuter rail rather than driving alone.

Rich Steinman – The approach at FTA and the U.S. DOT is to use the same value of time for all the surface transportation modes. There have been discussions on using different values of time for various modes, but no changes have been made. We have found it difficult to obtain realistic travel time estimates from the traditional travel forecasting models used by state departments of transportation, metropolitan planning organizations (MPOs), and other agencies. FTA has been working with FHWA on addressing these concerns. As a result, we typically do not consider travel times on the highway system in a transit BCA. We focus on the benefits to transit users.

Jack Wells – The issue of the impact of transit improvements on reducing highway congestion is analytically difficult. FTA and FHWA are working to improve our ability to analyze those impacts, and we hope to have new methodologies on that available soon. The U.S. DOT does allow different values of time for different portions of a journey. For example, dwell time at a transit stop is worth more than time riding in a vehicle.

The workshop has been excellent. Each presentation seems like a full semester course. BCA and the related topics the speakers have covered are new to most ports. We have a long way to go to catch up to other modes that have been using BCA for many years. Are any additional outreach efforts planned for ports?

Eric Gabler – We realize that most ports are not familiar with conducting BCAs. Many state departments of transportation and transit agencies are also not very familiar with BCA. The MPO in your area may be able to provide assistance in that they can provide you with needed data on population, employment, and travel forecasts.

Jack Wells – I would encourage applicants to contact staff at the Department, especially the modal agency related to your project, with any questions on BCA. There are staff with expertise in economics and BCA within each of the modal agencies.

Will the evaluation scores or other information from the first TIGER grants be made available?

Jack Wells – There were not numerical scores associated with the TIGER grant evaluations. Rather, there were general characteristics of projects, such as "highly recommended" and "recommended." It is not anticipated that any information on the evaluation of individuals' projects will be released to protect the privacy of the applications. We would be happy to share information on the overall evaluation process if that would be of help.

With freight projects related to rail and ports, am I correct that the public benefits and the private benefits should be shown separately? Also, are savings to shippers' public or private benefits?

Jack Wells – It is not necessary to show public benefits and private benefits separately. Whether savings to shippers are public or private benefits will depend somewhat on the situation. In general, savings to shippers would be considered private benefits because shippers are private companies. In general, however, a BCA should focus on the overall benefit to the economy, whether shippers and carriers enjoy those benefits privately or they are benefits to the general public. You might be interested in distinguishing public and private benefits for purposes of allocating the costs from a project between public and private partners. Such partnerships were an important element of the TIGER I grants. These partnerships might be between different levels of government, as well as with the private sector. Reflecting the extent that shippers, carriers, and other businesses benefit from a project is helpful in determining their share of the project cost, and would help support a proposed partnership.

Identifying the benefits to the public from projects that provide significant benefits to the private sector may also be important for justifying why American taxpayers are funding a project that supports private entities. Public benefits might focus on reducing congestion and reducing emissions. In general, these distinctions are secondary to demonstrating what the overall size of the benefits are.

When considering the BCA for a port, how would projects past their useful life be categorized when rehabilitation of infrastructure is essential for continuity of operations? I can demonstrate the local, regional, and national economic impacts, but how is that information translated into a BCA?

Eric Gabler – I think the example I highlighted presents the basic approach. Define the base case first. From the question, it sounds like the base case would be keeping the over-aged

facility operating the best you can. You might need to implement weight restrictions on roadways and conduct periodic repairs. Defining alternatives would be the second step. Alternatives might include rebuilding the facility, completing extensive rehabilitation, or rebuilding and expanding the facility. Each of these alternatives should be compared to the base case. A few applications in the TIGER I grant program assumed everything would stop operating due to over-aged facilities. If that were the case, some ports would already have stopped operating. There are always approaches to keeping facilities operating. As you know from automobiles, after an automobile gets past a certain age, it is very expensive to keep it operating and eventually it becomes cheaper to buy a new vehicle, but you can still keep it operating. Establish a realistic base case and examine alternatives in your analysis.

Jack Wells – In the base case, a port might be deteriorating and not be able to accommodate all the traffic it could if it were rebuilt. As a result, traffic may be diverted to other ports, which might lead to higher water and land transportation costs. Such a project could have local, regional, or national benefits depending on how widespread the customers of the port are. The savings in transportation costs to these customers is the main form of benefit.

Measuring Safety Benefits

Darren Timothy
Federal Highway Administration

Thank you, Jack. It is a pleasure to participate in this workshop. As you are aware, safety is one of the Department's five strategic goals. I will highlight the elements typically included in measuring safety benefits for highway projects and other transportation projects. Some of my comments are based on the review of the initial TIGER grant applications.

There are a few general concepts to keep in mind when you are examining the safety benefits from transportation projects. First, consider approaches that are more persuasive in quantifying potential benefits. Second, try to be specific, rather than general, in measuring possible safety benefits. Presenting the experience with similar local projects is a good approach. Third, consider conservative versus aggressive estimates. There is a certain amount of uncertainty associated with the various measures used in safety analyses. In general, using measures that are more conservative is suggested, especially if there is no local experience to draw upon. The robustness of the analysis is also important, especially with sensitivity analysis. The level of detail should be commensurate with the type of improvement being proposed.

Consistency in evaluation methods is also important. Having a consistent basis for comparing a range of projects is important. The safety impacts of infrastructure improvements typically focus on crash reductions, as do targeted safety enhancements and routine infrastructure improvements.

Potential sources of safety benefits include reductions in crash frequency, reductions in crash severity, and diversion of travel to safer alternatives. Diversion of traffic to safer alternatives will ultimately be translated into reductions in crash frequency.

Key indicators of safety benefits focus on the impacts of crashes. These impacts include fatalities, personal injuries, and property damage. The three key steps in measuring benefits are establishing a good baseline, projecting the impacts related to that baseline, and valuing those outcomes.

Establishing the baseline focuses on defining the no-build alternative or, in some cases the pre-build alternative. A number of elements are associated with establishing a good safety performance baseline. First, the baseline should be tied to the actual facility being improved. Second, the baseline should include multiple years of data if possible. Data should also be examined for the corridor or area where the project is located. The most recently available data should be used to account for any recent improvements or changes. We have seen a reduction in fatality rates recently, so it is important to use up-to-date information. It is also important to remember that the analysis is forward-looking and should include future projections for the continuation of the baseline or no-build alternative.

Projecting the impacts of the build alternative typically focuses on a number of elements related primarily to an engineering analysis. The analysis focuses on the impacts of the proposed TIGER II grant project. The analysis should examine the types of crashes in the area or on the facility, and changes anticipated based on the scope of the project. The interactive highway

safety design model can be used to model the impacts. Another approach is the use of crash modification factors. There is a Crash Modification Factors Clearinghouse that was developed under an FHWA contract. Caution should be exercised in using these sources, as a range of factors may be presented for the same type of improvement. All of these elements are included in the Highway Safety Manual, which is available at www.highwaysafetymanual.org.

In projecting impacts, it is important to account for changes in traffic flows. There may also be a need to account for diversion of travel to safer alternatives, which might include other routes, other facilities, or even other modes. Careful analysis of expected shifts in travel patterns and the expected safety performance of alternatives are key elements of the process.

There are sources of economic costs of crashes that can be used in valuing outcomes. These sources include damaged assets, medical costs, lost labor productivity, and WTP to reduce risks.

The Value of a Statistical Life (VSL) is one measure used to assess the WTP for reducing risks. VSL is not a value judgment on the worth of human life. Rather, VSL reflects the willingness to pay for reducing the risk of death. It is derived from studies of tradeoffs that people are willing to make for small changes in risks. The standard value currently used by the U.S. DOT is $6 million. More information on VSL Guidance is available at http://ostpxweb.dot.gov/policy/reports.htm.

There is also a WTP in reducing injuries. The value of preventing injuries is relative to VSL. A maximum abbreviated injury scale (MAIS) is available for the various injury levels using fractions of VSL as the measure. The fractions are higher for avoiding more severe injuries.

In addition, the direct economic impacts associated with crashes need to be valued. The highest economic costs are associated with the most severe injury category due to medical costs and loss of productivity. The economic costs associated with this category are slightly higher than the economic costs of a fatality.

Many of the injury reports that state departments of transportation and other transportation agencies rely on are based on the Police-Reported Injury Severity System (KABCO). The letters refer to the following injuries.

- K – Fatality
- A – Incapacitating
- B – Non-Incapacitating
- C – Possible Injury
- O – No Injury
- U – Injured, Severity Unknown

Converting these categories into the MAIS injury scale is an important step. A KABCO-to-MAIS conversion table is available or use from the National Highway Traffic Safety Administration (NHTSA). It is important to note that there are differences in the two reporting methods.

In summary, keys to measuring safety benefits include understanding the purpose and need of a project, the nature of the project, and making credible performance projections. Applying reasonable values to the anticipated safety benefits represents another key. Thank you.

Incorporating Livability Indicators into Transportation Policy and Project Evaluation
Todd Litman, Victoria Transport Policy Institute

Thank you very much. It is a pleasure to participate in this workshop. When I was young, I enjoyed reading about great adventurers who traveled to interesting places. That may have influenced my interest in this aspect of economics. Many economists like to stay in the current scope of analysis. My presentation will explore strange new worlds and seek out new civilizations in terms of economic analysis. My comments focus on livability indicators and BCA. It is important to remember that economics is not about money. Economics is concerned with human values and what people care about. Money is simply one way to measure values. My comments focus on what people value.

I need to emphasize that traveling into new territory can be dangerous. The U.S. DOT recently released its Strategic Plan, which contains references to livability and environmental sustainability. Not surprisingly, there has been some criticism about including these elements in the plan. For example, the May 2010 Surface Transportation Newsletter, published by the Reason Foundation, included an article that was skeptical of incorporating livability and environmental sustainability into the Strategic Plan.

It is quite understandable that we are vulnerable to criticism when we introduce new perspectives and new ideas. We need to be careful to make sure our analysis is as good as possible. We need to clearly explain what we are trying to accomplish when we add a new objective, a planning criteria, or a new category related to livability and sustainability. These challenges should not stop us. There is nothing wrong with trying to introduce new values, impacts, or objectives in transportation planning.

I will use the term sustainability planning as the overall framework for my comments. Sustainability planning balances economic, social, and environmental objectives. Many people think sustainability refers only to environmental sustainability. I define sustainability more broadly to include economic and social objectives. Sustainability balances all of these objectives. There are numerous subcategories of objectives and impacts within each of these categories. We need to emphasize that there is no one environmental objective, no one social objective, and no one economic objective.

Livability refers to the subset of sustainability objectives that directly affect people in a community. They often result in similar planning objectives, although with different perspectives and priorities. For example, both justify efforts to reduce pollution, although sustainability considers all pollution impacts, including climate change, while livability focuses on local air and noise pollution. Similarly, both support improving walking, cycling, and public transit, sustainability for long-term economic and environmental benefits, and livability because it tends to provide direct benefits by improving mobility for non-drivers, reducing local traffic impacts, and increasing public fitness and health.

Conventional planning tends to focus on established, easy-to-measure impacts at the expense of newer and more difficult-to-measure impacts. Sustainability planning can be defined as planning that considers all impacts regardless of how easy they are to quantify. Economic impacts have long been considered in transportation project evaluations, and environmental impacts have been added recently. Incorporating social objectives is a new challenge, however.

The social category includes impacts and objectives that do not fit well into traditional economic or environmental economics. These impacts include social equity, human health, cultural and historical factors, and public involvement. I think we can demonstrate that people really do care about these factors. We can demonstrate it by our own experience. For example, we can demonstrate it by individuals' WTP more for a house in a nice neighborhood. I think we can demonstrate through a number of techniques that there are significant benefits associated with these factors. Conventional economics has not given social benefits much attention.

There are many trends supporting change to more consideration of sustainability objectives. Examples of these factors include motor vehicle saturation, the aging of the population, rising fuel prices, and increasing urbanization. Other factors include increasing traffic and parking congestion, rising roadway construction costs and declining economic return from increased roadway capacity, environmental concerns, and health concerns. In addition, there are declining marginal benefits from increased mobility. Significant benefits are realized when you go from low levels of mobility to medium levels, but there are lower benefits from medium-to-high levels of mobility.

We can speculate that the relative value of an incremental improvement in the quality of an individual's neighborhood and related factors are more important as society becomes more mobile. The last century was the century of the automobile. I think this century will be the century of a more diversified transportation system. Per capita vehicle travel has stopped growing during the past decade. In the past, the U.S. DOT and state departments of transportation have focused on accommodating significant growth. In the future, we will need to develop a more diversified transportation system to meet changing needs.

There are a number of specific factors or planning objectives associated with livability. One objective is social equity, which is the overall fairness with which impacts (benefits and costs) are distributed. Other objectives include basic accessibility, which refers to the degree to which the transportation system provides access to essential services and activities, even to people with special needs. This is a subset of social equity. Affordability, which can be defined to include the cost savings and benefits for lower-income households, and community cohesion, or the quality of interactions among neighbors, represents other possible objectives. The local environmental quality experienced by residents and visitors, and the cultural and heritage values, which includes preservation of resources such as traditional communities, unique neighborhoods, and historic and cultural sites are also potential livability objectives. Finally, public fitness and health, defined as the amount of active transportation, such as walking and cycling, is still another objective.

Conventional transportation planning and economic evaluations typically consider travel time and congestion impacts, vehicle operating costs, per-mile crash impacts, and per-mile emissions. A number of factors are often overlooked in conventional evaluations, including the social factors. Examples of these overlooked factors include parking costs, total consumer costs, downstream congestion impacts, and land use impacts. The impacts on mobility options for non-drivers, equity impacts, and changes in active transportation and related health impacts represent other frequently overlooked factors. The crash, energy, and pollution impacts of changes in vehicle mileage are also not typically considered.

Critics of incorporating livability into BCA argue that current models are good and provide "conservative" estimates of the benefits of a particular policy or project. I would argue

that overlooking the significant impacts of livability and sustainability is a failure of current planning. Incorporating these additional impacts to the degree possible is actually the more conservative approach. For example, it is more conservative to improve walking, cycling, and public transit; implement demand management strategies; and support smart growth land use policies than to continue to favor automobile travel over alternatives by ignoring livability objectives. When people criticize innovation in an economic model, they are using the term conservative in the political sense – meaning that they do not want to change and are resisting innovation. I think it is more conservative or cautious to incorporate livability and sustainability impacts into BCA.

I have examined different approaches to monetize the impacts from these livability benefits. For example, I have analyzed the cost per vehicle mile of a typical automobile driving under typical conditions, which can be found in the report *Transportation Cost and Benefit Analysis,* available at www.vtpi.org/tca. Vehicle ownership, which represents the highest cost, is monetized by taking the average expenditures on a vehicle divided by average vehicle miles. Crash damages represent the second highest cost, with approximately half being external costs (born by other road uses) and half being internal costs (born directly by vehicle occupants). Vehicle operations and travel times are also significant cost components, although most conventional travel demand models ignore vehicle ownership costs. I believe many conventional models incorrectly value the cost associated with travel time because they assign a standard multiplier with wage rates. It appears that most people are willing to travel approximately 20 minutes a day, so there is relatively little time cost associated with a certain amount of travel. Being stuck in congestion has a very high level of time cost, however. Much of the travel time cost research has focused on those congested conditions.

Undervaluing social impacts may have numerous implications. Overlooking social impacts tends to undervalue planning decisions that reduce local traffic impacts such as traffic noise and air pollution, improved mobility for non-drivers, and improved transportation and housing affordability. It may also undervalue projects that help achieve equity objectives in other ways and projects that improve public fitness and health.

Currently, most of the conventional transportation indicators focus on how well the transportation serves motorists. Roadway level-of-service (LOS), average traffic speeds, and per capita congestion delay are examples of these types of indicators. MPOs and other regional agencies often use these measures to identify bottlenecks on the freeway and roadway system. These types of performance indicators skew funding toward expanding the surface transportation system. It defines the transportation problem as inadequate driving conditions and therefore justifies significant investments in expanding the system.

I am not dismissing congestion as a problem. It is a problem, but I argue that we need to develop multimodal LOS performance indicators. A recent project completed by Dowling and Associates provides examples of possible multimodal LOS factors. For example, LOS factors for walking include sidewalk/path quality, street crossing conditions, land use conditions, security, and prestige. Cycling LOS factors include path quality, street riding conditions, parking conditions, and security.

There are straightforward methodologies for quantifying these and other types of livability impacts. I am not suggesting it is easy to quantify all of these impacts, but economics have used the available methodologies to quantify other non-market impacts. Hedonic pricing

can be used by observing impacts on market goods, such as nearby property values or wages. Damage costs can be used to identify the value of damages from an activity, such as medical and disability costs of health damages. Stated preference surveys ask people how they would respond to various options. Compensation costs represent the amount that individuals or courts indicate people must be compensated for damages. Lifecycle analysis considers the cumulative effects of all impacts over the life of a project or activity. These methodologies can be used individually or in combinations.

Other speakers have noted the importance of travel time valuation. In most cases, personal travel is usually valued at 25-to-50 percent of prevailing wage rates for all types of travel. Drivers' travel time unit costs increase with congestion and unexpected delays. Passengers' travel time unit costs increase with discomfort related to crowding, dirt, odors, insecurity, and other factors, and are particularly high for uncomfortable and uncertain waiting conditions. I would argue that it is just as important to increase the comfort and convenience of travel as it is to increase travel speeds. Most models do not account for these factors. It is also important to remember that personal preferences vary. Some people prefer driving while others prefer transit or walking. Travel time unit costs are reduced if individuals can choose the mode they prefer.

There is a significant value to society if we provide multiple travel options to individuals for them to select the one that best meets their needs for a particular trip. Our current models do not account for this type of travel diversity. For example, an individual may bike to work on Monday when it sunny, drive on Tuesday to carry boxes to work, and take public transit on Wednesday when it is raining. These options provide economic benefits because people value them and social benefits because they reflect social values. We can make improvements in the way travel time is valued that I believe will justify significant changes in the alternative modes.

Transportation also has significant impacts on land use. Strategic land use development objectives focus on how we want our communities to look in the future. Reduced sprawl and preserving open space provides one example of a strategic land use development objective. Other possible objectives may focus on community redevelopment, increasing land use accessibility and transportation diversity, and improving walkability and neighborhood environmental quality. Each community will have different objectives. Transportation planners can then operationalize these objectives.

Travel survey data from Portland, OR indicates that neighborhoods with good transit services and mixed land uses have lower automobile mode split and higher walking, bicycling, and transit modes split than neighborhoods with only good transit services, and the remainder of the region. The daily vehicle miles per capita are much different for the three areas, with 9.8 daily vehicle miles per capita for the good transit and mix land use neighborhoods, 13.3 daily vehicle miles per capita for the good transit only neighborhoods, and 21.8 daily vehicle miles per capita for the remainder of the region. A 50 percent reduction in daily vehicle miles per capita can be realized from certain land use conditions. These figures do represent some self-selection, but even accounting for those factors, research indicates that transportation and land use planning factors have a large effect on travel behavior.

Community livability impacts may include reduced traffic-related noise and local air pollution exposure and preservation of community, cultural, and historic resources. Other possible impacts are improved neighborhood safety and security, enhanced walkability, and

greater community cohesion. These types of impacts tend to be reflected in local property values and business activity.

Social equity impacts might include providing an equal share of public resources for people with equal needs and savings and benefits to lower-income people. Other equity impacts focus on basic mobility and increased opportunity to people who are physically, socially, or economically disadvantaged. I believe that society does value these types of benefits. While some of these impacts are considered in the transportation planning process, I think there is great merit in developing a more formal framework to account for these factors in the transportation planning process.

My research indicates that smart growth land use policies can provide substantial safety benefits, as highlighted in the report *Save Travels*, which is available at www.vtpi.org/safetrav.pdf. Smart growth communities have lower annual traffic deaths per 100,000 population than communities characterized by urban sprawl. This situation is often overlooked because most safety analyses consider risk per vehicle mile, which does not account for the additional accidents occurring from transportation and land use decisions that increase per capita mileage, or the safety benefits that occur from transportation planning decisions that reduce total vehicle mileage. I think the per capita unit of measure is the appropriate measure for assessing social impacts. It measures people, not miles.

Another impact of the transportation system relates to the amount of physical activity individuals undertake. The public fitness and health benefits from walking and cycling can be quantified. There is research underway in Europe and New Zealand examining these benefits. I recently conducted a workshop in Atlanta for the Center for Disease Control (CDC). The CDC is interested in developing a North America version of the Heart Model, which is a model that quantifies the health benefits or total value of increasing physical activity. Research in New Zealand has identified the value of each additional mile of walking and cycling. If we are going to put a value on safety improvements, which reduce risk, we can also put a value on walking and cycling.

Local economic development impacts often receive a lot of attention and may be considered a livability objective. In terms of economic benefits, I think the local employment generated from a project may actually be one of the lesser impacts, even though it gets all the attention. Other economic impacts, such as affordability, are often overlooked. Rather than increasing incomes by 10 percent, if we can reduce household financial burdens by 10 percent, we can achieve the same objectives. As a result, I think affordability is a very important economic benefit. Increased affordability allows businesses to attract employees in areas with high living costs, providing a direct economic activity impact.

Input/output table analysis can determine the impact of household expenditures on regional economic activity. Transportation decisions that reduce household expenditures on gasoline generate a number of regional jobs. A million dollars spent on petroleum produces less than five jobs, whereas general consumer expenditures produced 12 or 13 jobs. This information suggests that if households reduce expenditures on petroleum they have more money to spend on goods and services, which increases economic activity in the region. My research suggests that this change is very significant and should be included in local analyses.

Questions

The U.S. consumes approximately 20 billion barrels of petroleum a year, of which three quarters is transportation-related. Much of the petroleum we consume is imported. You did not mention it, but there would also be political and security benefits associated with reducing household petroleum consumption.

Todd Litman – You are correct that reducing petroleum consumption would have numerous benefits, including political and security benefits. I also like your focus on the benefits rather than the costs. A reduction in the U.S. dependence on imported oil has economic, political, and security benefits.

Public transportation is an important part of this initiative. Cities have authority over land use and zoning. How can transit agencies work with communities to realize transit-friendly land use and development patterns?

Todd Litman – Transit is half of the equation. Simply running a bus or a train produces few benefits. The real benefits of a diverse transportation system will occur if you have high-quality public transit meshed with support strategies. These strategies might include TOD, improved walkability, smarter parking management, commute trip reduction programs, pay-as-you-go insurance, and car sharing. There is a whole set of strategies that fit together. Analyzing only one or two of these strategies will not show the full economic benefits. We need to focus on the full set of investments and policies that optimize benefits and meet consumers' needs. We are not doing that now.

How would you quantify elements of green infrastructure, such as forest cover and maintaining water quality?

Todd Litman – The starting point is to define the strategic land use and development objects for a community or area. The various transportation alternatives can be analyzed based on these objectives. A basic principle of good planning is that individual short-term decisions support strategic long-term goals. The starting point for good planning is to have agreed upon, well articulated strategic goals. The need to quantify, or put a dollar value on each individual impact lessens if you have strategic goals. We know there is a value to preserving open space for a variety of reasons. If preserving open space is a strategic objective, then transportation projects can be evaluated to determine if they support or contradict the objectives. A more specific example is regions that have adopted an imperious surface tax for storm water management.

State of Good Repair
Rabinder Bains
Federal Highway Administration

Thank you, Jack. I appreciate the opportunity to participate in this session. My presentation will define the term state of good repair (SGR), outline the TIGER II evaluation criteria for SGR, and describe life cycle cost analysis.

The U.S. DOT TIGER II guidance defines SGR as "improving the condition of existing transportation facilities and systems, with particular emphasis on projects that minimize life-cycle costs." The term SGR has been used more commonly in the past few years. It focuses on maintaining existing transportation facilities.

There is no specific threshold at which an asset may be considered an SGR. It is more about making investment decisions so that improvements are made to the system to minimize the user and agency costs over the life of the asset. The SGR is a broader concept than asset management practices. It emphasizes the need to align investment decisions to long-term financial and economic impacts, as well as a commitment to good asset management practices.

There are four criteria in the TIGER II guidelines used for evaluating an SGR project proposal. These four criteria are: 1) whether the project is part of, or consistent with, relevant state, local or regional efforts and plans to maintain transportation facilities or systems in an SGR; 2) whether an important aim of the project is to rehabilitate, reconstruct or upgrade surface transportation assets that, if left unimproved, threaten future transportation network efficiency, mobility of goods or people, or economic growth due to their poor condition; 3) whether the project is appropriately capitalized up front and uses asset management approaches that optimize its long-term structure; and 4) the extent to which a sustainable source of revenue is available for long-term operational and maintenance of the project.

To address the first objective, applicants need to show that the proposed project is consistent with the agency's goals to maintain investments in an SGR. Information should be presented to support the practice of SGR. Applicants should outline the agency's asset management practices and goals, and illustrate commitments to preservation policies. Applicants should also present the asset inventory and the current condition of the asset, such as the percentage of the pavement in good, fair, and poor condition. The identified investment needs for the system should be summarized. The specific metrics, both current and future condition and usage, of the project should be described, along with how these metrics relate to the agency's goals for preservation.

To address the second objective, applicants should describe the threat to future economic efficiency, growth, and stability if the asset is not improved through the proposed project. Applicants should estimate future agency and user costs if the asset is not improved. Examples of impacts include increases in the frequency and the cost of repairs, increases in user travel costs, increases in user operating costs, and increases in safety risks. Ultimately, use of the facility may be restricted or the facility may be closed all together, if the improvements are not made.

Analyzing the impacts of not improving the transportation facility involves a number of steps. First, project the condition of the asset over the analysis period with minimum maintenance. Second, project the timing and the length of the maintenance periods. The maintenance periods may vary by the age of the asset, with more frequent maintenance as the asset ages. Third, determine if the asset can continue in operation without the improvement, or if restricted use or closure is needed. Finally, identify the traffic management plan if detours or reducing capacity are implemented. The costs to users from the detours or reduced capacity should be analyzed.

The anticipated impact on economic activity from not improving the asset also needs to be examined. Steps in this process include identifying the origins and destinations of users, identifying the types of businesses in the area, and determining the likely impact on the businesses located in the area and nationally. Possible impacts on businesses include continuing existing operations, relocating to another area, or closing.

A number of elements should be included in assessing the user impacts of not improving a transportation asset. These elements include projecting future traffic, forecasting traffic impacts during maintenance and restricted usage, and estimating travel time costs due to detours or reduced speeds. Other elements focus on estimating operating costs due to poor conditions or detours, and assessing safety impacts.

The impacts on the operating agency also need to be examined. The cost of maintenance should be estimated. The cost of operations management during maintenance incurred by the agency should also be identified.

The economic impacts of not improving the facility, restricting use, and closing the facility should be examined. The analysis should identify any reduction in business activity, identify any increase in business operating costs, and identify possible risks to future business operations.

The third of objective relates to demonstrating if the proposed project is appropriately capitalized. To meet this objective, the application should demonstrate that the planned investment will be adequate to meet the demand of the system, while minimizing the agency and user cost over the life of the asset.

Life Cycle Cost Analysis (LCCA) is one tool available to compare alternative investment strategies. LCCA compares agency costs and user costs to select the alternative that minimizes agency and user costs over the life of the asset. LCCA is used only when the benefits of each alternative are the same. FHWA guidance for conducting LCCA for pavements is available at http://isddc.dot.gov/OLPFiles/FHWA/013017.pdf.

There are a number of procedural steps involved in conducting an LCCA. These steps include establishing alternative design strategies for the analysis period, determining performance periods and activity timing, estimating agency costs, and estimating user costs. Calculating the net present value, analyzing the results, and re-evaluating alternatives represent the final steps. I will briefly describe each of these steps.

In defining feasible alternative design strategies, each strategy should be considered as a combination of an initial investment and necessary supporting maintenance and rehabilitation activities. The analysis period is the time period over which future costs are evaluated. The appropriate analysis period may vary for different strategies. The analysis period should be long enough to allow for one cycle of major rehabilitation for each alternative.

The performance period for each alternative should be identified. The maintenance schedule to keep the asset in operation should also be identified for each alternative. The maintenance schedule will vary for different strategies based on the asset life cycle and activity cycle. Activity charts can be used to identify the appropriate maintenance schedule.

The agency costs estimate should include the initial asset cost and the maintenance costs over the lifetime of the asset for each alternative by year. Examples of cost categories include design and engineering, land acquisition, construction, reconstruction, rehabilitation, and preservation and routine maintenance. Estimating the remaining serviceable life of an asset will account for differences in the remaining asset life among the alternatives at the end of the analysis period. Sunk costs, which are those costs already incurred and which do not make a difference to the decision at hand, should not be included. Certain maintenance costs may not differ between alternatives. For example, the cost of snow removal on a highway that has the

same capacity under each alternative will be the same. Only the costs that differ among the alternatives should be included.

User costs include travel time costs, operating costs, safety costs, and personal costs. The schedule and length of maintenance operations should be identified for each alternative. Future demand for the service should be projected. Alternative modes and route choices should be identified for time periods when the asset is out of use or has limited capacity. The impacts of reduced service to users during construction should also be identified. These impacts include diversion costs related to increased travel distance and increased travel time, reduced capacity, safety issues, and trip-time reliability.

The fourth objective addresses providing a sustainable source of revenue for long-term operations and maintenance. Information on the agency's sources of funding for maintenance and operations should be presented. The future preservation needs of the system should be described, along with the goals of the agency to meet these needs. Providing a funding commitment for the future maintenance and operational costs of the particular asset is important.

The following equation is used to estimate the NPV of a project. The NPV should be estimated for each alternative. Comparisons can be made of the NPV of different alternatives.

$$\text{Net Present Value} = \text{Initial Cost} + \sum \text{Future Costs} \left[1/(1+i)^n\right]$$

Sensitivity analyses can be performed to test the robustness of the assumptions. Finally, the design strategies can be reevaluated as necessary to minimize certain costs. For example, a wider shoulder design may reduce user costs during future construction, making a certain design strategy more feasible.

In summary, the TIGER II application should include three major elements. First, it should include any quantifiable metrics of the facility's current condition and performance. Second, it should project the condition and the performance, including an explanation of how the project will improve the facility or system's condition. Third, information on performance and long-term cost structure, including calculations of avoided operations and maintenance costs and associated delays, should be included.

Economic Competitiveness
Kenneth Button
George Mason University

Thank you, Jack. I am pleased to participate in this workshop. I have been asked to talk about the economic competitiveness impacts of transportation projects. I would highly recommend two books, both by Adam Smith, to help provide a context for my comments and those of other speakers today. The first book is *A Tretis on Moral Sentiments*, which addresses many of the points Todd Litman discussed. The second book is *Wealth of Nations*, which focuses on economic competitiveness and job creation.

The following definition from the British Treasure in 1965 captures the key elements of a BCA. "Cost-benefit analysis is a practical way of assessing the desirability of projects, where it is important to take a long view **(in the sense of looking at repercussions in the further, as well as the nearer future)** and a wide view (in the sense of allowing for side-effects of many

kinds on many persons, industries, regions, etc.), i.e., it implies the enumeration and evaluation of all relevant costs and benefits."

I have highlighted the portion "in the sense of looking at repercussions in the further, as well as the nearer future" because I think it is especially important for two reasons. The first reason relates to the increasing importance of environmental considerations and sustainability in transportation. Lower rates of discount are being used in response to these considerations. The Stern Report in the U.K. recommended a discount rate of less than one percent, which requires a very long future to replace your cost effectiveness. Using a discount rate of 8 percent-to-9 percent requires looking only 13-to-14 years into the future to replace your cost effectiveness. The second reason is that economic competitiveness is a long-term activity. It takes a long time to plan, design, and construct transportation projects. Thus, the impact of transportation project competitiveness will occur over a long period.

Improved competiveness refers to the enhancement of the relative economic position of one region compared to other regions. Improved competitiveness means that the relative prices of goods and services being exported from that region fall compared to the goods and services being imported into the region. The outcome is a flow of money into the region from other areas as residents buy more goods and services from the region. In ideal circumstances, the other areas also gain by being able to buy cheaper goods and services produced in the region.

As other speakers have mentioned, BCA is conceptual. A BCA is dependent on the client. I was involved in completing three BCAs on renewing the Glasgow Canal in Scotland as a recreational facility for three different clients. The first client was the City of Glasgow, the second was the British Government, and the third was the European Union. The BCAs were different in each study, reflecting the different interests and objectives of these three different groups. For this workshop, we are considering the economic competitiveness of the U.S.

Transportation is a "lubricant" in the economic system that facilitates production, trade, and the movement of factors of production. Optimal transportation provision is required to optimize the efficiency and competitiveness across regions and countries. Transportation improvements may either occur within a region or a country, affecting the efficiency of local industry, or between regions or countries, affecting the cost of trade between regions or countries. Transportation also allows for the movement of factors of production, which includes labor and capital. For example, low cost airlines resulted in approximately 4,000 Polish workers moving to Great Britain over a two-year period. This move resulted in a significant change in the labor force and the competitiveness of Britain. Too much transportation, production, and trade will be inefficient, just as is too little transportation leads to suboptimal production and trade.

There are two types of transportation improvements that impact economic competitiveness – projects that improve efficiency of industries and improvements that enhance the flow of goods to other countries. For example, a transportation improvement in Montana may result in industries in the state becoming more efficient, including those that export goods to China. Thus, internal transportation improvements may increase the economic competitiveness of the U.S.

Other types of transportation improvements, such as ports, facilitate the movement of goods and people, including exporting and importing goods. Improvements at a port may not

impact the efficiency of industries, but industries may benefit through enhanced access to overseas markets and improved competitiveness.

Transportation may affect economies and economic competitiveness in many different ways. In terms of investment impacts, short-term jobs and related income will have little effect on competitiveness. Maintenance and operation of the transportation system, which may be considered secondary impacts, produce long-term job creation, but also have little effect on competitiveness. Tertiary impacts resulting from new investments in industries because of enhanced transportation will affect competitiveness and may have overall economic benefits for the economy. Pecuniary impacts, which represent a shift in the economic structure or production function for the region as a result of enhanced transportation will affect competitiveness and may have overall economic benefits. For example, transportation investments in Florida have supported the state's tourism industry.

There are a number of complicating factors, which may influence transportation and economic competitiveness. One complication is the difference between trade creation and diversion. Trade creation results in an overall increase in economic activity that benefits the regions involved. Trade diversion transfers benefits from one region to another. In other words, one region may get more employment but only at the expense of less employment in another region. Strict BCA at the national level focuses only on trade creation.

A second possible complication is the problems of what can be termed as "second best." In a "perfect" world, markets are complete and competitive decisions about transportation are based on profits. In practice, however, regions subsidize their industries to stimulate exports and restrict imports using tariffs, quotas, and other similar techniques. Further, manufacturing and service industries in the regions are monopolistic. Transportation itself is not provided in competitive markets. It may be manipulated by regions to their individual advantage. For example, some communities subsidize air service. Examining profits for transportation in these situations as a guide to policy is not generally meaningful.

A third complication is what can be called the "Appalachian effect." Transportation investments may lead to a reduction in the competitive position of a region that has improved transportation access to other regions. This situation occurred in the Appalachian region in the U.S. This effect may occur if a region has no major comparative advantage in production, which was the case in the Appalachian region, and other regions benefit from significant economies of scale. Thus, their combined costs of production and transportation are lower than firms based in the region. The region's factors of production, such as labor, are mobile and migrate out of the region.

In another example, improving transportation to ports to help U.S. export industries may well have adverse effects on the national economy. These improvements may stimulate imports more than exports if U.S. industries are otherwise uncompetitive. It is important to consider these factors in your analysis.

There are different methods that may be used to measure economic competitiveness impacts. Using some type of impact analysis that includes economic multipliers represents a standard approach. Economic multipliers can be difficult to estimate with transportation projects and there is a tendency to exaggerate. They do not take into account local conditions and they ignore reverse multipliers on regions that pay for the investments or lose relative competiveness. Econometric models represent a second possible approach. These models require large amounts

of data, and specifying the equations. There are estimation issues with the use of these models. Subjective quantitative assessment represents another approach. Consulting with retired experts, who have no vested interest in a project, can assist in obtaining unbiased results.

There are also a number of approaches for dealing with the imperfections in the system. First, there will always be some form of trade diversion associated with any form of investment. Separating impacts by industry may be of use. A new job in a distressed area may be more important than a lost job in an area with a surplus of labor. Second, tracing the flows of goods and services is beneficial. Not all imports are necessarily bad in the long run. For example, until the end of 2009, Germany was the world's largest exporting country. Germany exports machine tools to China, which in the long-term may be used to build machines that make machine tools and then China would not need to import them from Germany. Understanding the structure of the region's economy is important, along with the focus on main sectors. Third, transportation does not just affect production; it affects what is available to produce things. As a result, factor movements should be considered. Fourth, most firms are profit driven. Considering the implications of transportation on both costs and revenues is important. Finally, provide a sensitivity analysis on your results.

I will conclude by highlighting a few challenges with considering economic competiveness in a BCA. A first challenge is data limitations. We do not have good data on the link between transportation and economic competitiveness. A second challenge relates to forecasting problems. We do not do a good job of forecasting the costs of the transportation investment, forecasting the traffic flow effects, or forecasting transportation effects on competitiveness. The U.K. actually has a manual on adjusting traffic forecasts. A large number of forecasts were reviewed in developing the manual. The review found that most forecasts for transit services overestimated use and underestimated costs. When BART was constructed in the San Francisco Bay Area, the traditional four-step travel demand forecasting model estimated a 15 percent change from private vehicles to transit. An economic model indicated at 6.3 percent change. The initial change was 6.2 percent.

Another challenge is estimating how competitive a region will be in 10, 15, or 20 years without the transportation investment. Defining the alternatives can help in this estimate. The potential for double counting represent another challenge. Isolating transportation investment when there are packages of investments represent still another challenge. A final challenge relates to spatial spillovers. While the U.S. is a separate country, it is linked to Canada and Mexico. These relationships may be even stronger in 20 or 30 years. Competitiveness is tricky and awkward to address, but should be included in a BCA.

Questions

How can a transit capital project compete with other projects for funding related to economic competiveness?

Kenneth Button – Certain attributes are important to economic development. Skilled and creative workers expect a high quality of life. They expect a good lifestyle and good access to transportation. Many people want good access to transit and use transit rather than driving. If this program focused on increasing the economic competiveness of the U.S., you probably would not invest heavily in transportation. Free markets and high quality education and training are key elements of global economic competiveness. Transit can stimulate people to live, work, and interact with others.

Do you think energy efficiency could also have an impact on overall economic productivity and economic competiveness, especially in regions that rely on energy imports?

Kenneth Button – I do not think it helps much. I think having the right price for transportation and the right price for fuels is important and will provide the right mix. A lot depends on where an area is in the trade cycle.

You mentioned the Stern Report and the discount rate of under one percent. The TIGER I and II guidelines use seven percent and three percent sensitivity. What would your guidance be on the discount rate?

Kenneth Button – The discount rate is important, but it is a judgment call. One approach is to use a standard discount rate across all sectors, which was done in the U.K. during the late 1960s. Another approach is to use different rates for environmental factors and for factors traded in the market. The implications for global warming are infinite and could have significant impacts on all sectors of the economy. There may be a case to use a lower discount rate for environmental factors to reflect the uncertainty associated environmental benefits. Another approach is to use the same discount rate, but apply different measures of uncertainty to different benefits. This approach may be the most appropriate.

Measuring Environmental Benefits
Charles Griffiths
Environmental Protection Agency

Thank you Jack and good afternoon. My comments focus on measuring environmental benefits. I will summarize the general approaches and highlight a few examples.

The benefits of environmental protection are estimated the same way benefits are estimated for the other categories the speakers have covered. We quantify the WTP for the environmental commodity. The value is determined by what consumers are willing to spend for a commodity, not by what the analyst believes is the value. Because environmental protection is a public good, the benefits of a policy are the sum total of each affected individual's WTP for that policy. Placing a price on environmental improvements is not easy, however. Unlike the private sector, we do not readily observe prices for clean air, clean water, and other environmental improvements.

Approaches are available for measuring the monetary benefits of environmental improvements. One approach, market valuation, focuses on the prices for some environmental benefits, such as the production and the commercial value of increased fishing and tree stands. A second approach is non-market valuation, which uses revealed preference and stated preference to identify the costs associated with different environmental benefits. Revealed preference methods examine real behavior and what people actually spend in terms of time and labor to obtain better environmental quality. We can indentify if people drive further to reach a better recreational fishing location. We can use hedonics and link higher wages to taking on riskier jobs or paying higher housing prices to live in an environmentally friendly area. We can also examine averting behaviors. For example, we can examine actions people take to avoid the negative impacts of reductions in environmental quality, such as buying bottled water. We can also consider the cost of illness approach, which examines how much people have to spend to deal with an illness.

Stated preference methods include surveys, interviews, and other techniques to obtain information on what people value. These methods were used to attempt to identify peoples' perception of the Exxon Valdez oil spill. Stated preference techniques provide information on what people indicate they will do or have done.

Environmental benefit categories include mortality and morbidity risk, market products, recreation activities and aesthetics, value ecosystem functions, and nonuse values. Mortality and morbidity risks represent the largest category of benefits measured by the EPA. The EPA measures the reduced risk of cancer fatalities, acute fatalities, cancer, asthma, and nausea. The commonly-used economic value methods include averting behaviors, hedonics, and stated preference. For the market products category, we can measure the market prices of food, fuel, and timber. The recreation activities and aesthetics category includes wildlife viewing, fishing, swimming, hiking, and scenic views. Economic valuation methods include production functions, averting behaviors, hedonics, recreation demand, and stated preference.

Measuring the ecosystem functions category is a little more difficult. Examples of benefits include climate moderation and flood moderation. Production functions, averting behaviors, and stated preference surveys represent examples of methods to measure these benefits. Non-use represents the final environmental benefits category. These benefits result from knowing that the various environmental elements are present, rather than from actual use. These benefits are measures through stated preference surveys and other related techniques.

There are standard methods for valuing mortality risk reductions. Economists examine how people react to risks in their own lives and how they make tradeoffs between small risks and income. We can examine the prices paid for bottled water, organic food, smoke detectors, and other safety devices. We can assess the risk reductions people believe they are receiving from these purchases. The amount workers are paid to take on riskier jobs can also be examined. We can ask people what they are willing to spend to reduce mortality risks in surveys.

These tradeoffs, applied to small risk changes over a group of people, have historically been summarized as the VSL. It is important to remember that we are not placing value on an individual's life. Rather, for example, if each of 10,000 people exposed to a life-threatening hazardous chemical would pay $700 to mitigate the risk, in total one statistical life is "saved" and the total WTP is $7 million. Thus, the VSL is $7 million.

The guidance from the U.S. DOT on VSL is $5.8 million in 2007 dollars and a sensitivity analysis using $3.2 million and $8.4 million. This guidance is different from the EPA's income-adjusted estimate of $7.7 million in 2006 dollars. The U.S. DOT guidance should be used for the TIGER II applications.

Morbidity, which focuses on sickness rather than death, is harder to measure. The length and the severity of an illness influence the impact. Using WTP to measure the complete value of avoiding a health outcome is a better approach. Stated preferences from contingent valuation studies provide values for chronic illnesses and acute respiratory effects. If necessary, we can use the cost of illness, which captures the direct dollar savings to society of reducing a health effect. It ignores the value to individuals of reduced pain and suffering, however. It is generally considered a lower bound when no WTP estimates are available, although it may not be lower when factoring in insurance costs. The cost of illness is not a true reflection of WTP. We would anticipate that as income levels increase, people are more willing to spend more for environmental benefits. The costs of illness do not necessarily reflect income levels.

Economists use the damage function approach in this analysis. First, the damage to the environment or individuals from the situation or condition is estimated. Second, a value is assigned to that damage. The reduction in damages associated with the effects is estimated and the benefits are calculated in monetary terms. The benefit analysis draws on results from other disciplines, including epidemiology, toxicology, chemistry, biology, risk assessment, and sociology. A dose response curve is often needed to estimate the health impacts of reducing a pollutant. We also need to be able to value the change or the effect to provide a meaningful economic impact.

Ecological benefits are examined in a similar manner, except the focus is on improvements in human well-being that are derived from ecosystem services. For example, we can estimate how much people are willing to spend on recreational fishing.

The total value of a resource reflects an individual's WTP to preserve or maintain a resource in its current state. There are two components to total value – use value and non-use value. Use value is the economic value associated with the use of a resource, such as visiting a recreation site. Use value is typically measured using travel cost models or other market methods. Non-use values are all of the remaining components of total value that arise independent of use, which may include existence values. Non-use values can be particularly important in cases where the resource in question is unique or special in some way and when the loss is irreversible. Stated preference surveys represent the typical method of identifying non-use values.

As an example, reducing air pollution may have numerous benefits. Examples of health benefits include reduced risk of premature death, chronic illness, hospitalization, respiratory illnesses and symptoms, and sick days. Another benefit from reducing air pollution is increased productivity for outdoor workers. Possible welfare benefits include visibility improvements, improved agricultural and forest yields, reduced damage to structures, reduced cleaning costs, and reduced ecosystem damages.

These elements are included in the environmental economic analysis, which uses some type of damage function approach. These benefits may be measures through air quality models, epidemiology studies, economic analysis, and other approaches. Air quality models project how air quality is expected to change. Epidemiology studies provide concentration-response relationships to predict how health effects will change. Economic analysis predicts the worth of changes in health and welfare effects.

Continuing the air quality example, the health effects of particulate matter (PM) and ozone were examined. These health effects included mortality, chronic bronchitis, hospital admissions, asthma ER visits, acute respiratory symptoms, and asthma attacks. Other health impacts were lost work days, worker productivity, myocardial infarctions, school absence rates, and cardiovascular ER visits. It is important to emphasize that not all variables produce all the impacts. Using a defined dose response curve helps address this concern.

The welfare effects of air pollution were also examined. Identifying the effects that can be quantified is important. Possible effects include visibility in national parks, visibility in residential areas, reductions in household cleaning expenditures, and reductions in nitrogen deposition to sensitive estuaries. Reductions in acid deposition, improved agricultural yields, and improved forest yields represent other possible effects.

The analysis indicated that by 2030, the rule would reduce oxides of nitrogen (NOx) emissions by over 800,000 tons and diesel PM by over 126,000 tons. A total of 9,600 premature mortalities would be avoided, 5,700 cases of chronic bronchitis would be avoided, 16,000 nonfatal heart attacks would be avoided, and millions of acute respiratory symptoms and lost work days would be avoided. The annual benefits of the rule in 2030 were estimated at over $80 billion relative to $2 billion in costs. Chapter 9 of the Regulatory Impact Analysis provides more information on the BCA in this example. The report is available at http://www.epa.gov/nonroad-diesel/2004fr.htm#ria.

A number of sources provide information on the unit values of benefits from reduced air pollution. The 1990 Clean Air Act Amendments required the completion of two BCA studies on the impact of the Clean Air Acts. The first Retrospective Study examined the impacts of the Clean Air Acts from 1970 to 1990 (1997 - Appendix I). The second Prospective Study examined the potential benefits from 1990 to 2010 (1999 - Appendix H). Both of these references are available at http://www.epa.gov/air/sect812/. The reports include the dose response curves used in the analysis. The dose response curves translate reductions in pollutants to the health effects. These values change over time and need to be updated periodically.

The Regulatory Impact Analyses for the National Ambient Air Quality Standards, which are updated every five years, is available at http://www.epa.gov/ttn/ecas/ria.html#ria2007. Sections of interest include Ozone (2008 - Chapter 6), Lead (2008 - Chapter 5), Sulfur Dioxide (2009 - Chapter 5), and Nitrogen Dioxide (2010 - Chapter 4). The values are reported for 2020 income levels. The Regulatory Impact Analyses for the Light-Duty Vehicle Greenhouse Gas Emissions Standards (2010 – Chapter 7) is available at http://www.epa.gov/otaq/climate/regulations/420r10009.pdf.

The social cost of carbon (SCC) is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. We all know that vehicle emissions produce carbon dioxide (CO_2), which contributes to global warming. The SCC focuses on the impact of the monetized damages associated with the increase in CO_2 emissions. The SCC is the increase in aggregate income that would make society just as well off as a one-unit decrease in greenhouse gas emissions (GHG) in a particular year. It is intended to include – but is not limited to – changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services due to climate change. The following is the equation for determining the SCC.

$$SCC_t \equiv \frac{dY_t}{dE_t} = -\frac{\partial W_t / \partial E_t}{\partial W_t / \partial Y_t}$$

An interagency work group selected four SCC values for use in regulatory analyses. The agencies involved included the EPA, U.S. DOT, and the Department of Environment. Staff from the Council of Economic Advisors and the Office of Budget chaired the work groups. Table 3 presents these values in dollars per metric ton of CO_2 reduced. The benefits from reduced emissions can be estimated by multiplying changes in tons of CO_2 in any year by using the SCC value for that year. The NPV of the benefits can be calculated by dividing each future year benefits by one plus the appropriate discount rate and summing across all affected years.

Table 3. Social Cost of One-Ton Reduction in CO_2, 2010 – 2050 (in 2007 Dollars)

Year	5% Avg	3% Avg	2.5% Avg	3% 95th
2010	4.7	21.4	35.1	64.9
2015	5.7	23.8	38.4	72.8
2020	6.8	26.3	41.7	80.7
2025	8.2	29.6	45.9	90.4
2030	9.7	32.8	50.0	100.0
2035	11.2	36.0	54.2	109.7
2040	12.7	39.2	58.4	119.3
2045	14.2	42.1	61.7	127.8
2050	15.7	44.9	65.0	136.2

As shown in Table 3, the interagency group suggested a range of four values – approximately $5, $21, $35, and $65 for a one-ton reduction in CO_2 in 2010. Those values, which represent the social cost of carbon, increase over time. This increase is due to the increase in the damage function as more carbon is introduced into the atmosphere, as well as an increase in population and income levels.

Questions

Concerning the VSL, is it acceptable in a BCA to add some measure of the present value of the earning foregone by premature death or is that a form of double counting?

Charles Griffiths – The VSL is the WTP for the small reduction in risk, so the present value of lost earnings due to premature death would not be included.

Kenneth Button – In the U.K., we used to try to account for lost earnings. The problem is that a retired individual using up their previous income may have a negative value of life. The VSL approach addresses this concern.

Measuring Costs

Arlee Reno, Cambridge Systematics, Inc.

Thank you, Jack. The other speakers this afternoon have discussed estimating the benefits from various transportation projects. My comments focus on measuring costs, which are generally considered as the costs of the transportation facility or project. In reality, most of the benefits are reductions in costs to users and to society as a whole, compared to the situation without the new facility. I will discuss the different cost categories, updating or forecasting costs, and references that may help in conducting BCAs.

The TIGER II Interim Notice stresses the need to document all costs and benefits by year. Data needed to analyze safety costs include the number, rate, and consequences of crashes. Information for assessing livability measures includes user costs, improved choices and accessibility, and services for disadvantaged, elderly, and disabled individuals. Assessing the state-of-good-repair focuses on condition, performance, and improvement to long term costs. Economic competitiveness addresses long-term efficiency, cost competitiveness, and productivity. Environmental sustainability focuses on energy, GHGs, avoidance of environmental costs, and mitigation or reduction in costs.

An economic analysis primer prepared by FHWA is available at http://www.fhwa.dot.gov/ infrastructure/assetmgmt/primer.cfm. The primer provides a framework for examining the benefits and costs associated with transportation projects. Agency cost types include design and engineering, land acquisition, construction, reconstruction and rehabilitation, preservation and routine maintenance, and mitigation. Other agency costs relate to safety, preservation, freight, and the environment. User cost types focus on delay and time costs, crash costs, and operating costs. Externality cost types include emissions, noise, and other related factors.

A few reminders may be of help when measuring costs. First, both future costs and future benefits should be presented in constant un-inflated dollars, as illustrated in the Federal Register Volume 75, Number 79, April 26, 2010, page 21714. Second, it is not legitimate to present costs in today's dollars and benefits in inflated dollars. Third, the recommended discount rates are to be applied to costs and benefits expressed in constant dollars for all future years. Finally, remember that the discount rate is not about inflation; it is about preferences for what it is worth to receive the same constant dollar value in different future years.

Other speakers have highlighted many of the potential cost categories. Capital costs include equipment and preliminary costs, and have a relationship to life-cycle costs. Operating costs include both agency and user costs. Other cost categories focus on travel time, safety and security, and equity. Environmental costs are associated with GHGs, sustainability, community livability, and water quality.

Applicants are assumed to have solid and detailed capital and equipment cost estimates available. There is often a need to update these costs to today's dollars. The primary source for updating capital cost is the Bureau of Labor Statistics (BLS) Producer Price Indices available at http://www.bls.ppi. The BLS will have a *Focus on Prices and Spending* series beginning this month. Very useful secondary sources of information are John Semmens' data series publications *Price Trends for Major Roadway Inputs* at http://www.mtkn.org/products/pt/

index.htm and Ken Simonson's Association of General Contractors (AGC) Data Digest articles at http://www.agc.org/.

As an example, Semmens compiles the following highway and bikeway capital costs to today's dollars by BLS code number.

- Asphalt (WPU5810112)
- Construction Labor (CEU2023730008)
- Diesel (WPU05730302)
- Gasoline (WPU0571)
- Lumber (WPU081)
- Plastic Construction Products (WPU072106)
- Portland Cement (WPU13220161
- Steel Rebar (WPU101708)
- Highway and Street Construction(PCUBHWY)

For applicants interested in updating transit capital costs the following items from BLS would be of use. Again, the BLS code number is provided.

- Elevators/Escalators (WPU114201)
- Buildings for Stations/Facilities (PCUBBLD - - BBLD - -)
- Other Facility/Station Elements (PCUBMNR - - BMNR - -)
- Guideways - Steel Mill Products (WPU1017)
- Catenary, Contact Rail - Nonferrous Wire/Cable (WPU1026)
- Communications (WPU1176)
- Systems - Electrical Machinery And Equipment (WPU117)
- Other Highway-Type Elements (PCUBHWY)

In addition, the American Public Transportation Association (APTA) has files of every agency's costs for all vehicle types.

There may also be a need to convert soft or preconstruction capital costs into today's dollars. Applicants are expected to show all costs for the proposed investment, including any remaining preliminary costs for project development. FTA, APTA, and the transit industry have developed analyses of preliminary or soft costs. A useful document is the Transit Cooperative Research Program (TCRP) Report 138 *Estimating Soft Costs for Major Public Transportation Fixed Guideway Projects*. This document is available at http://gulliver.trb.org/Publications/PubsTCRPProjectReports.aspx.

Applicants are also expected to show life cycle costs for the proposed investment, and how the investment impacts life cycle costs. Excellent life cycle cost guidance and explanations of procedures can be found at the FHWA Office of Asset Management website at http://www.fhwa.dot.gov/infrastructure/asstmgmt/lcca.cfm. Some assets will have longer asset lives than 20 years, as acknowledged in the Notice. Applicants should consult the U.S. DOT if more guidance is needed on how to present residual values in the analysis.

Applicants are expected to show costs and benefits in constant dollars for the same year. Capital costs should be updated between previous years and the present using the producer price index data series for the specific costs. Operating, travel time, and other costs should be updated between various past years and the present using the consumer price index (CPI). CPI

information for previous years is available at the BLS website at ftp://ftp.bls.gov/pub/special.requests/cpi/cpiai.txt.

Applicants are expected to base their agency operating cost estimates on their experience with similar projects. Any differences should be explained. The HERS model has operating costs by vehicle type, which are periodically updated with indices. HERS ST is available through the FHWA Office of Asset Management. The download is available at http://www.fhwa.dot.gov/infrastructure/asstmgmt/hersprep.cfm. In addition, the American Automobile Association (AAA) has private vehicle costs in *Your Driving Costs*, available at http://www.aaaexchange.com/Assets/Files/200948913570.DrivingCosts2009.pdf.

Detailed costs for freight operations are available in several U.S. DOT reports. The *Freight Benefit Cost Study: Phase III – Analysis of Regional Benefits of Highway-Freight Improvements* report is available at http://www.ops.fhwa.dot.gov/freight. The *Economic Costs of Freight in Bottlenecks* report is available at http://www.fhwa.dot.gov/policy/otps/freight.cfm.

Other speakers have discussed the importance of travel time and travel-time costs in BCA. All vehicle types have travel time and operating cost parameters in HERS and HERS ST. Data are available by vehicle type and by business versus personal travel. The derived outputs from running the HERS model include overall travel values for vehicle types ranging from $20.42 to $22.16 for personal travel and $30.87 to $37.48 for business travel. The average value of time is $24.86 for all travel on rural roads and $23.96 for all travel on urban roads. While research by HLB and others has shown higher costs for time spent in delay, guidance from the U.S. DOT should be followed in any modifications.

When estimating current travel-time costs and forecasting future year travel-time costs, it is important to remember that benefit-cost models already incorporate or embed travel-time costs and other costs. Forecasts of increases in future year travel time costs for personal vehicles may not be realistic, as they will depend on growth in income per capita. Income per capita does not always grow – particularly for those groups whose travel is income-limited. For example, examining per capita real income and the percentage changes by income level from 1967 to 2008 indicates an increase across all income quintiles from 1967 to 2000, but a decrease across all income quintiles from 2000 to 2008.

In terms of highway safety costs, all highway crash types have safety cost parameters in HERS and HERS ST for fatalities, injury, and property damage-only crashes. In addition, the AAA has produced a very useful document on safety related costs, which is available at http://www.aaanewsroom.net/Assets/Files/20083591910.CrashesVsCongestionFullReport2.28.08.pdf. The American Automobile Association (AAA) concluded that crash costs exceed congestion costs. Safety costs should be updated to today's dollars with CPI adjustments.

The U.S. Department of Energy's (DOE) Alternative Energy Outlook (AEO) provides forecasts of energy prices and modal energy usage rates by year, with alternative scenarios, which should be used as the basis for GHG emissions estimates. The AEO can be found at http://www.eia.doe.goc/oiaf/aeo. Energy prices are provided in Table 3, and Table 7 contains model usage factors and forecasts. The HERS model is periodically updated with AEO's modal usage forecasts.

Examining the on-road fuel economy for new light-duty vehicles from 1975 through 2006 model years' by sales-weighted horsepower and miles per gallon (mpg) highlights the

importance of the Corporate Average Fuel Economy (CAFE) standards. The fuel efficiency of vehicles, as measured by mpg, increased dramatically from 1978 to 1981, when the CAFE standards were in effect. Technology has improved tremendously since that time, but rather than improving mpg, it has been used to increase the vehicle horsepower. Technologies today have the capacity to increase fuel efficiency.

The U.S. DOT's *Greenhouse Gas Report to Congress* includes estimates of the impacts on GHG emissions from generic actions. These estimates can be used to estimate the GHG emissions consequences of projects. The report is available at http://ntl.bts.gov/lib/32000/32700/32779/DOT_Climate_Change_Report_-_April_2010_-_Volume_1_and_2.pdf. Agencies should calculate estimates of GHG impacts using modal fuel efficiencies from sources such as the AEO. It is important to note that future light duty vehicle mpg will be increasing.

As noted by other speakers, analyses on the equity impacts of transportation infrastructure projects are sparse. The Notice calls for applicants to examine the impacts of proposed projects on accessibility and transport services and costs for target groups, including economically disadvantaged populations, non-drivers, the elderly, and persons with disabilities. The portions of household budgets spent on transportation by income groups are available in the consumer expenditure survey data on the BLS at http://www.bls.gov/cex/2008/aggregate/quintile.pdf. Related tables for each year of interest are available.

The Puget Sound Regional Council (PSRC) analysis of user benefits versus the costs of tolls provides one example of an equity analysis for a toll project. The savings from using the toll facility were calculated for different income groups, and different public and commercial user groups. These savings were then compared to the tolls paid. The percent of benefits per dollar of tolls paid ranged from 2.24 percent for low-income drive alone home-based trips to 97.99 percent for trips made by medium-sized trucks.

A second example from the Massachusetts Institute of Technology (MIT) examines the distributional impacts of a carbon tax and a lump sum rebate. The results indicate that a carbon tax as a percent of income is higher for lower income households than higher income households. A lump sum rebate as a percent of income addresses this disparity.

Overall costs are inter-related. The costs of investing and operating can impact demand and usage on a multimodal basis, and cost analyses should be integrated. Glen Weisbrod and I recently completed a TCRP project that provides detailed guidance on the successive calculations of inter-related costs of various modes and their impacts on wider or broader economic factors. The project report, *Economic Impact of Public Transportation Investment*, is available at http://www.apta.com/resources/reportsandpublications/Documents/economic_impact_of_public_transportation_investment.pdf. Figure 11 from the report illustrates the multimodal costs interrelationships.

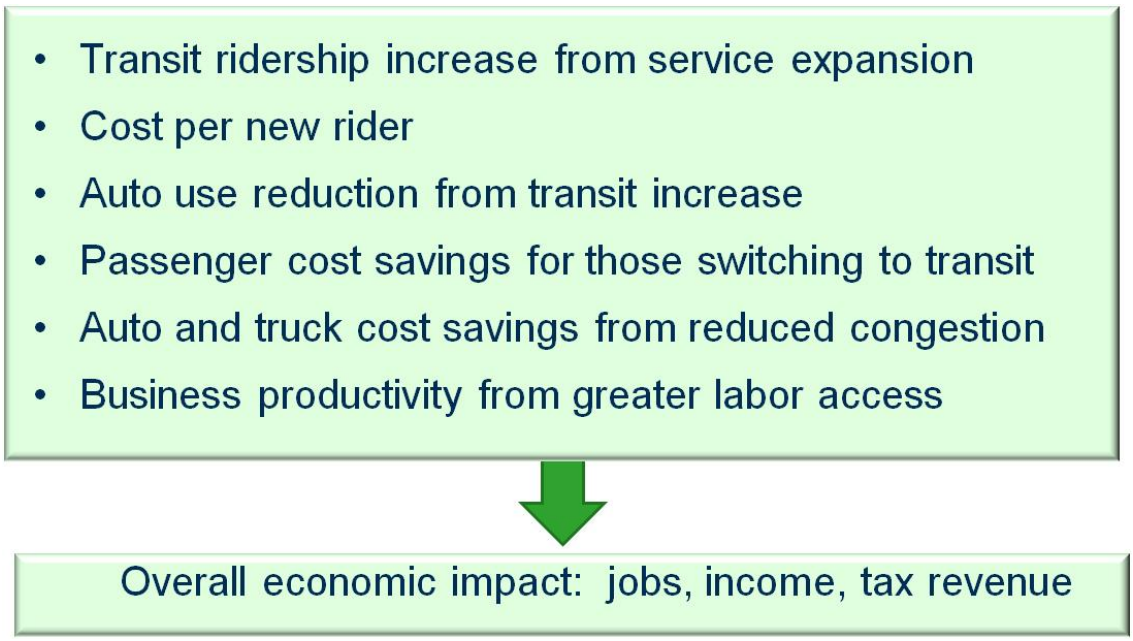


Figure 11. Multimodal Costs Inter-Relationships.

It is also important to remember that costs are embedded in models. Ira Hirshman, who was here, has done a lot of work identifying the costs and benefits incorporated into different models and cross classifying them. If embedded costs are directly useable, then the models results do not need adjustment. If embedded costs need adjusting, however, applicants should take extra care when making adjustments in this process. The types of costs covered are dependent on the types of models used in the analysis. The costs embedded in models should be reviewed and any needed adjustments inside the models or through post-processing should be made. As a reminder, use constant dollars, and discount all future years' benefits and costs similarly.

A number of speakers have highlighted examples from the U.K. The Eddington Report identifies an evolution of economic analysis and BCA, culminating in a framework called *Value for Money*. This framework incorporates wider economic benefits and monetizes other benefits to the extent possible. The work of Glen Weisbrod on the TREDIS model and by others on the HEAT model, has sought to broaden BCA toward a similar framework. The U.K. Transport Ministry has developed a *Transportation Appraisal Guidance* (TAG) framework. The TAG provides evolving modular guidance on specific performance objectives and economic methods, and links performance objectives to economic analysis consistently and transparently. The guidance is regularly updated, organized by topic area, and is available at http://www.dft.gov.uk/webtag/documents/index.php. The TAG units address a very wide range of topics. Applicants may want to examine the different topics, but U.S. parameters will need to be used in any analysis.

A few final comments related to the U.S. DOT TIGER grant requirements. First, build on your experience with the previous TIGER grant program. Second, follow the U.S. DOT's instructions, which specify best practices. Third, review all cost parameters and update costs.

Fourth, if you utilize models with embed costs and benefits, remember to take extra care when making adjustments. Finally, follow the U.S. DOT's notice, not any other advice, and present a realistic analysis.

Workshop Wrap Up

Katherine Turnbull
Transportation Economics Center

Thank you, Jack. It is a pleasure to provide a few closing comments. It is also a pleasure to assist the U.S. DOT in facilitating this informative workshop as the first task of the new Transportation Economics Center. We are pleased and delighted to be selected for the Center and we look forward to working with the U.S. DOT and all of you as we move forward with other activities.

It has been a very productive day. It has also been a long day, so I will keep my comments brief. All of the speakers did an excellent job conveying complex concepts and information in an understandable manner. From some of the comments during the question periods and breaks, it appears that the wealth of information presented was a bit intimidating, overwhelming, and, as some participants noted, a full academic semester in one day.

In organizing the workshop, we wanted to provide a good overview to demystify BCA. At the same time, we wanted to drill down to provide detailed information on methodologies, issues, and examples. All of the speakers did an excellent job of introducing their topics and presenting applications and examples to assist with completing BCAs for the TIGER II grant applications and other purposes.

We also tried to give you some new terms, acronyms, and ideas for your dinner conversations. You can now impress your family and friends by dropping terms like hedonics, the social cost of carbon, agglomeration, WTP, and the value of statistical life. I am sure you are just waiting to try your expanded vocabulary on others.

We began this morning with Dan Graham providing an overview of the general BCA concepts and approaches. We heard about the differences between BCA and economic analysis from Glen Weisbrod and the job creation and real estate values from David Lewis. The panel of representatives from FTA, FHWA, FRA, and MARAD provided practical insights into conducting BCAs projects in the various modes. They highlighted some of the challenges, and described experiences with the TIGER I grant applications.

The speakers in the afternoon discussed measuring the benefits associated with the U.S. DOT's five goals. Darren Timothy addressed safety, Todd Litman covered livability, Rabinder Bains described the state of good repair, Ken Button examined global competiveness, and Charles Griffiths highlighted environmental sustainability. Arlee Reno's presentation on measuring costs provided a good conclusion to the workshop.

A number of challenges associated with conducting BCAs emerged from the presentations. These challenges highlight the need for further research to advance both the state-of-the-practice and the state-of-the-art in conducting BCAs.

Data, especially accurate data, continues to be an ongoing challenge. We all know that obtaining good data is not easy. We need data to drive BCAs, travel forecasting models, and other analyses. Identifying methods to obtain the data needed for these models and analysis techniques would be beneficial. Providing ongoing funding for data collection and analysis is also important.

Avoiding double counting in BCAs was noted by many speakers. Providing additional guidance and outreach on accounting for various benefits would be of help. Measuring the private sector benefits and differentiating the public sector benefits from the private sector benefits was noted as a challenge, especially for rail and port projects. There is less experience in using BCA with port and rail projects. Sharing best practice BCA examples for all modes would be beneficial, but would be especially useful with port and rail projects.

The discussion this afternoon associated with livable communities identified a number of challenges. Possible research to address these challenges includes defining elements of livable communities, identifying possible benefits, and identifying methods to measure these benefits. Collecting the needed data is also an ongoing challenge. I think there is still much to be learned with defining and measuring livability and sustainability goals.

The trend toward transportation performance measurement and performance management represents still another challenge. Determining how to better link BCA and performance measurement represents another area for additional research.

I would like to thank all of the speakers again for excellent presentations. I would also like to thank Jack Wells and the other U.S. DOT staff for all their work in organizing the workshop. Finally, thank all of you for your attention and active participation over a long, but productive day.

APPENDIX A – REGISTRATION LIST

Chandana Achanta, Office of Management and Budget
Teresa Adams, U.S. Department of Transportation
Rabinder Bains, Federal Highway Administration
Marty Baker, Maryland Department of Transportation
Monica Bansal, Metropolitan Washington Council of Governments
Timothy Barkley, Federal Railroad Administration
Carl Barrick, Office of Management and Budget
Eric Beightel, U.S. Department of Transportation
Phil Bell, New Yor State Department of Transportation
Christpher Behr, HDR, Inc.
Wayne Berman, Federal Highway Administration
Shailen Bhatt, Federal Highway Administration
Jeff Bishop, Oregon International Port of Coos Bay
John Bolecek, U.S. Department of Transportation
Amy Bonitz, Bonitz Palmer LLC
Susan Borinsky, Federal Transit Administration
Levon Boyagian, Boyagian Consulting, LLC
Bill Brody, ProvPort, Inc., The Port of Providence
Ann Brown, City of Stamford
Kenneth Button, George Mason University
Homer Carlisle, American Public Transportation Association
Jose Castedo, Federal Aviation Administration
Mary Cearley, Texas Transportation Institute
Dave Chien, Research and Innovative Technology Administration
Paul Clary, Baltimore Development Corporation
Greg Cohen, American Highway Users Alliance
Faith Cole, Federal Transit Administration
Nathaniel Coley, Federal Highway Administration
David Connolly, Office of Management and Budget
Heather Contrino, Federal Highway Administration
Karen Darch, Villiage of Barrington
Ed Davis, RJ Corman Railroad
Donnie DeBerry Jr., Maryland State Highway Administration
Patrick DeCorla-Souza, Federal Highway Administration
Norman Emerson, Emerson & Associates
Jeff Ensor, Parsons Brinckerhoff | PB Strategic Consulting
Vincent Fang, MacroSys, LLC
Ed Farmer, Millennium Strategies LLC
Zack Fields, Congressman Connolly
Kim Fisher, Transportation Research Board
Michael Flynn, New York City Department of Transportation
Tony Furst, U.S. Department of Transportation
Eric Gabler, Maritime Administration
David Garcia, Cameron County Regional Mobility Authority
Travis Gibbons, Jordan & Associates, Inc.
John Giorgis, Federal Transit Administration
Suzy Glucksman, The Advocacy Group
Lisa Gordon, Atlanta BeltLine Inc.
Daniel Graham, Center for Transportation Studies
Katie Grasty, Federal Transit Administration
Jeanne Griffin Moore, City of Brooksvilel
Charles Griffiths, Enviromental Protection Agency
Jonathan Groeger, MACTEC Engineering and Consulting, Inc.

Stephane Gros, HDR, Inc.
Kumudu Gunasekera, Parsons Brinckerhoff
Titin Handojo, MACTEC Engineering and Consulting, Inc.
Tricia Harr, Federal Transit Administration
Bob Harris, Alabama State Port Authority
Ira Hirschman, Parsons Brinckerhoff
Jeffrey Horn, U.S. Department of Transportation
Susan Howard, North Carolina Department of Transportation
Caitlin Hughes Rayman, Maryland Department of Transportation
Mary Huie, Federal Highway Administration
Jim Hunt, Federal Highway Administration Office of Operations
Max Inman, American Association of State Highway and Transportation Officials
Peter Ivory, Federal Aviation Administration
Brian Jacob, U.S. Department of Transportation
Michele Jacobson, Lea+Elliott
Jeanette Janiczek, City of Charlottesville
Joe Jarrin, New York City Department of Transportation
Yi Jiang, Purdue University
Rick Johnson, Maryland Department of Transportation
Ram Kancharla, Tampa Port Authority
Jeff Knowles, Pennsylvania Environmental Council
Akira Kondo, Federal Aviation Administration
Betty Krier, U.S. DOT Office of Inspector General
Laura Labosky, City of Stamford, CT
Bill Larson, Simmatec USA
Dan Leach, Federal Aviation Administration
David Lewis, HDR Engineering
Bill Linde, Federal Highway Administration
Yuh Wen Ling, U.S. Department of Transportation
Eron Linn, Dallas Area Rapid Transit
Todd Litman, Victoria Transport Policy Institute
David Luskin, Federal Highway Administration
Sergio Maia, Federal Transit Administration
Allen Mattes, Federal Aviation Administration
Jim McCarville, Port of Pittsburgh Commission
Sean McClure, Manufacturing Policy
Justin Merritt, Town of Smithfield
Andrew Metrick, President's Council of Economic Advisers
Bobby Mills, The Advocacy Group
Mindy Milos-Day, Oakland Township
Ruchi Mohinder, Jacobs Engineering
Susan Monteverde, American Association of Port Authorities
Ralph Morris, Federal Aviaton Administration
Richard Morrison, Fort Bend County
Cheryle Mosier, Central Ohio Transit Authority
Kim Nelson, Office of Management and Budget
Aubrey Oliphint, National Highway Traffic Safety Administration
Kevin O'Malley, St. Lawrence Seaway Development Corporation
Joel Palley, Federal Railroad Administration
David Parkhurst, National Governors Association
Michael Patella, Federal Transit Administration
Don Pickrell, U.S. Department of Transportation
Martin Pietrucha, Larson Institute, Penn State University
Michael Pisciteli, City of New Haven
David Plazak, Transportation Reserach Board/SHRP 2
Neil Pogorelsky, HDR Decision Economics
James Pol, U.S. Department of Transportation
Mani Poola, City of Stamford
Jeremy Price, Rep. Don Young

Kate Quinn, Federal Highway Administration
Jeff Reczek, Federal Transit Administration
Robena Reid, Federal Transit Administration
Arlee Reno, Cambridge Systematics, Inc
Pam Richmond, Lake~Sumter Metropolitan Planning Organization
Zoe Robertson, Southeastern Pennsylvania Transportation Authority
Bob Robeson, Federal Aviation Administration
Deborah Rosen, University of Rhode Island
Joel Rubin, Conkling, Fiskum and McCormick
Jim Saklas, Federal Highway Administration
Robert Samis, Federal Aviation Administration
Wayne Sandberg, Washington County Public Works
Dawn Savo, City of Bridgeport
Pete Sepulveda, Cameron County Regional Mobility Authority
Jerrod Sharpe, U.S. Department of Transportatioin
Margie Sheriff, Federal Highway Administration
Richard Sherman, The Seneca Group LLC
Richard Steinmann, Federal Transit Administration
Carl Swerdloff, U.S. Department of Transportation
George Thurston, Federal Aviation Administration
Darren Timothy, Federal Highway Administration
Mary Lynn Tischer, Federal Highway Administration
Toni Trombecky, Federal Aviation Administration
Polly Trottenberg, U.S. Department of Transportation
Katie Turnbull, Texas Transportation Institute
William Valerio, Philadelphia Museum of Art
Jerry Vest, Genesee & Wyoming Inc.
Leif Wathne, American Concrete Pavement Association
Rich Weaver, American Public Transit Association
Glen Weisbrod, Economic Development Research Group
Jack Wells, U.S. Department of Transportation
Jeffrey Wharff, Federal Aviation Administration
Yi-Ching Wu, Georgia Tech University
Weixian Xiong, Maryland State Highway Administratioin
Phyllis Yeats, Port of Orange
Carol Zimmerman, Battelle
Kathleen Zubrzycki, Southeastern Pennsylvania Transportation Authority

APPENDIX B – WORKSHOP AGENDA

8:15 a.m. – 9:00 a.m.	Registration Pick Up in U.S. DOT West Building Entrance and Continental Breakfast Outside Oklahoma Room
9:00 a.m. – 9:10 a.m.	Welcome – Jack Wells, U.S. Department of Transportation
9:10 a.m. – 9:20 a.m.	Message from the White House – Andrew Metrick, Council of Economic Advisers
9:20 a.m. – 10:00 a.m.	Introduction and Overview – Daniel Graham, Imperial College, London
10:00 a.m. – 10:30 a.m.	Benefit/Cost Analysis and Economic Impact Analysis – Glen Weisbrod, Economic Development Research Group
10:30 a.m. – 10:45 a.m.	Break
10:45 a.m. – 11:15 a.m.	Job Creation and Real Estate Investment Benefits – David Lewis, HDR
11:15 a.m. – 12:15 p.m.	Challenges of Applying Benefit/Cost Analysis: A Modal Perspective – Representatives from FHWA, FTA, FRA, and MARAD
12:15 p.m. – 1:15 p.m.	Lunch (Sandwich Bar Available for $10 per Person)
1:15 p.m. – 2:45 p.m.	Measuring the Benefits of DOT's Strategic Goals – Safety – Darren Timothy, Federal Highway Administration – Livable Communities – Todd Litman, VTPI – State of Good Repair – Rabinder Bains, Federal Highway Administration
2:45 p.m. – 3:00 p.m.	Break
3:00 p.m. – 4:00 p.m.	Measuring the Benefits of DOT's Strategic Goals – Economic Competitiveness – Kenneth Button, George Mason University – Environmental Sustainability – Charles Griffiths, Environmental Protection Agency
4:00 p.m. – 4:30 p.m.	Measuring Costs – Arlee Reno, Cambridge Systematics, Inc.
4:30 p.m. – 5:00 p.m.	Wrap Up – Katherine Turnbull, Transportation Economics Center

Publication No. FHWA-HOP-10-008

Toll-Free “Help Line” 866-367-7487