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Applying Benefit-Cost Analysis to Freight Project Selection: Lessons From the Corps of Engineers

Final Report

Prepared for
National Cooperative Freight Research Program
Transportation Research Board
of
The National Academies

Prepared by Acadia Group, LLC

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December 2012

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DISCLAIMER

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FINAL REPORT CONTENTS

List of tables and figures iii
Author acknowledgements iv

Abstract v

Executive summary vi

1. INTRODUCTION, HISTORY, AND BACKGROUND 1
Introduction 1
The US Navigation System 2
The Corps Planning and Project Approval Process 3
Step 1. Problem Perception 4
Step 2. Requires Federal Action 4
Step 3. Study Problem and Report Preparation 5
Step 4. Report Review and Approval 5
Step 5. Congressional Authorization 5
Step 6. Project Implementation 5
Funding Sources 6

2. BENEFIT-COST ANALYSIS: A PROCESS HISTORY 7
A Foundation for Benefit-cost Analysis 7
Early Parallels in Private-Sector Transportation Analysis 7
Corps of Engineer Economic Practices, 1900-1983 8
1983 to the Present 11

3. CURRENT CORPS PLANNING AND ANALYSIS PROCESSES 15
The Broad Decision Making Structure 15
Quantifying Benefits and Costs Under the Principles and Guidelines 15
The Treatment of Externalities 18

4. OTHER AGENCY PROCESSES 21
Non-Corps Federal Transportation Projects 21
State-Sponsored Transportation Projects 23
Externalities in Non-Corps Project Evaluations 24

5. DATA AND ANALYTICAL TOOLS 27
Analytical Tools 27
Transportation Data 30
Analytical Tools and Data Going Forward 32

6. IMPLICATIONS for practitioners AND STUDY CONCLUSIONS 34
Summary of Findings 34
Practical Implications 35

References 37

Interviews Regarding Corps Benefit-Cost Analysis (BCA) 41

Annotated reading list 46

LIST OF TABLES AND FIGURES

Figure 1: Map of the Inland River System, p. 3

Prepared at the Corps of Engineers Institute for Water Resources, Fort Belvoir, Virginia.

Figure 2: Transportation Responsibility and Funding, p. 22

Prepared by the author.

Figure 3: Navigation Benefits as Calculated by ORNIM, p. 29

Prepared by the author.

Figure 4: Less Perfectly Inelastic Demands, p. 30

Prepared by the author.

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ABSTRACT

This research examines the issue of federal transportation infrastructure evaluation based on the experiences and methodologies used by the U.S. Army Corps of Engineers in its selection, construction, maintenance, and operation of both coastal and inland navigation projects. Special attention is given to the estimation of project benefits and the treatment of market externalities. The Corps of Engineers methodologies are contrasted to similar processes used by the federal agencies that administer infrastructure development for other transport modes, with the finding that variations in evaluation criteria lead to systematic difference in transportation infrastructure outcomes and are inconsistent with the development of truly multimodal freight transportation networks. The research concludes with suggested measures intended to remedy these outcomes.

EXECUTIVE SUMMARY

In its broadest application, the current research aims to inform future discussions of federal transportation infrastructure development based on the practices that govern the evaluation of inland and coastal navigation projects by the U.S. Army Corps of Engineers (Corps). The experiences of the Corps are particularly useful toward this end because they are long-lived, well documented, and at least of late, the subject of considerable scrutiny. Where it is important, the analytical methods and evaluation criteria used by the Corps are contrasted with the methods and criteria applied to other federal transportation infrastructures. These comparisons are not intended to confer favor on any particular set of standards. Instead, they are designed to demonstrate how seemingly modest variations in the application of economic principles can result in significantly different estimates of project value. The study concludes with a summary of the changes that would be needed to reconcile the transportation project evaluation process across all transport modes. The resulting agenda is not comprehensive, but it does highlight some of the most salient areas.

The Corps' responsibility for developing, operating, and maintaining navigable waterways in the United States dates to the later decades of the Eighteenth Century. By the late 1800s, decisions regarding when and where to invest public funds in navigation infrastructure were routinely guided by comparisons of potential public gains, and by 1902 these comparisons had formally emerged as early versions of benefit-cost analyses. Over the course of the Twentieth Century, requirements for the calculation of project benefits and associated costs steadily gained momentum, though obvious political interests sometimes eclipsed this practice. By the early 1980's requirements for formal benefit-cost analysis and directives governing their conduct had been incorporated into the principles and guidelines that legally direct federal investment in both inland and coastal navigation capacity.

The navigation project evaluation principles, now in place, have been routinely criticized for their economic underpinnings and the methods through which they are applied. Still, the Corps processes are more extensive and restrictive than the criteria applied to federal investments in other modal infrastructures. Indeed, the harshest criticisms of the Corps have come when analysts deviated from prescribed standards, not when they have adhered to them.

These standards call for the calculation of project benefits that strictly measure the national-level economic efficiency gains attributable to building, maintaining, and operating navigation structures. This process quite correctly gives no attention to where these benefits accrue and it clearly excludes economic outcomes that represent simple wealth transfers rather than actual increases in consumer and producer surplus. Indeed, the most repeated criticisms of current Corps methodologies are that they incorrectly bias benefit estimates downward through their asymmetric treatment of *external* costs and *external* benefits.

By comparison to navigation project criteria, the rigor applied to the evaluation of federal investments in other transport modes has often been lacking. Historically, benefit-cost analyses have been required less frequently within formal investment decision processes and, when these analyses have been performed, they have exhibited almost no consistency in methodological approach, so that comparing the benefits of one project to another has been nearly impossible. (This example was clearly displayed during the initial US Department of Transportation (USDOT) TIGER application process and led USDOT to begin training to improve the quality of future applications.) Among the community of navigation advocates there is a clear sentiment

that this apparent variation in evaluation criteria has led to a systematic bias against waterway investments.

Without considering the merits of this claim or exploring the many reasons why non-navigation transportation investments have been treated differently, it is clear that federal policy is moving toward the more consistent treatment of potential transportation improvements. Perhaps, this convergence in approach is a response to the complaints of waterway proponents, but it more likely reflects the not so subtle changes in the nation's requirements for overall freight mobility. Environmental concerns, land-use issues, fiscal constraints, and unprecedented levels of modal congestion have combined to require that we now achieve much greater levels of transportation capacity from every federal investment in aggregate transport network capacity. These pressures have, in turn, led to an increased focus on multimodal transportation corridors where distinct modes provide substitute capacity for one another and intermodal activities seamlessly combine individual modes in door-to-door transport.

Increasingly, proposed federal investments in roadways, aviation, and rail industry capacity require the support of rigorous benefit-cost analysis, so that they can be evaluated with other potential improvements. This movement toward parity in modal comparisons is, no doubt, a good thing, but for the current generation of planners, trained in mode-specific methods, it has also introduced a great deal of uncertainty as transportation policy-makers grapple to find and implement the appropriate set of cross-modal standards.

Toward this end, the national experience in the evaluation of navigation projects is instructive. This experience has provided numerous lessons that point to a clear set of improvements that will better support evaluation standards. Five such implications are summarized here. They include:

1. A clear standard for qualified benefits that focuses exclusively on all efficiency gains, including externalities, and which carefully excludes economic outcomes that simply reflect transfers of economic well-being;
2. A set of analytical methods that are not restricted to transportation activities, but which capture the whole of the supply chain benefits and costs that are attributable to transportation infrastructure improvements;
3. The development of analytical techniques that clearly recognize that capacity deficiencies can actually choke off activity by causing system patrons to abandon planned trips or shipments they would otherwise undertake;
4. The reconciliation of long-standing differences in the determination of planning horizons, discount rates, and other financial parameters; and
5. A steadfast commitment to the development and ongoing support of the data resources needed to engage in defensible project evaluations.

1. INTRODUCTION, HISTORY, AND BACKGROUND

INTRODUCTION

Publicly funded transportation infrastructures share many characteristics that are common across transport modes. Typically, these projects are large in scale, long-lived, and closely tied to expected beneficial outcomes. They also routinely serve the transportation needs of populations that live far away from actual project locations. Finally, these infrastructures are generally part of a larger transportation network or system, where the efficiency and capacity of one component is closely tied to the configuration and performance of other system elements.

These characteristics, when combined with other decision considerations, quickly become the complicated analyses needed to guide public sector investment decisions. Adopting an analytical framework that is too simple can lead to results that ignore critical information and support poor choices. On the other hand, trying to account for the full range of inter-relationships that characterize investment alternatives can produce an intractable framework that yields overly fragile conclusions. (There exists a fine line between too much and too little information when considering infrastructure investment.) Thus, the first step in evaluating a proposed infrastructure investment often involves agreeing on the analytical methods used to evaluate the project's likely benefits and costs.

Traditionally, transportation projects have been considered public good, where public sector money is spent to construct and maintain the infrastructure necessary to support the movement of people and goods, with benefits that accrue to the broader community. The need to link markets in this way provided the impetuous for many of our major transportation infrastructure programs, programs such as in the Eire Canal, the transcontinental railroads, the Interstate highway system, and other endeavors that include a federal aviation network and modern navigation.

The processes and rules needed to guide public investment developed in parallel with the growth of the nation's transportation system. Through a variety of means, most transportation infrastructure projects have been funded with a mix of federal, state, and local moneys. These projects combined to form an advanced transportation system that once seemed beyond reproach. Today, however, growing congestion, ballooning maintenance costs, system security concerns, and routine funding shortfalls suggest that existing planning and investment program frameworks for freight mobility should be reconsidered.

One of the greatest challenges to effective multimodal planning lies in the haphazard way in which overall systems design is organized. Within the U.S., distinct (and often competing) entities have responsibility for financing, planning, constructing, and operating the nation's modal networks. Over time, each mode develops investment processes based on industry-specific need. Within the public sector, infrastructure needs typically reflect the concerns of users or are based on the characteristics of available data. Some of these processes also consider broader, external impacts, but others do not.

Private sector investment decisions, primarily rail, are a function of perceived rates of return, the cost of acquiring capital, and the time horizon of investors. Absent public sector involvement, these investment decisions do not reflect potential impacts on non-market participants.

Within the public sector, the variety of approaches used to evaluate potential transportation investments has led to a predictable disparity in the types and scale of new infrastructure projects. Specifically, within the current context, planning guidelines for waterway

investment must follow the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (hereafter termed the Principles and Guidelines) with attention to the additional guidance provided by the Council on Environmental Quality, which was released in 2009. Highway projects are evaluated much differently under a varied set of standards, despite having the same gross study outline of estimating costs and benefits to assist, as the network benefits and forecasts are treated in a much different manner. Further, the planning guidelines that apply to aviation projects are different from both the standards applied to proposed waterway projects and guidance used to evaluate roadway construction. This means that at least three different methodologies are used to evaluate transportation investments that sometimes compete for the same pool of infrastructure funds.

Among the governmental entities that may require the formal calculation of project benefits and costs, none is more experienced, consistent, or complete than the US Army Corps of Engineers. The Corps often has required benefit-cost calculations since the late nineteenth century and has relied on routine, prescribed sets of processes since 1902. Moreover, the Corps not only plans network investments, it also builds, maintains, and operates these infrastructures. Other federal transportation agencies provide funding, but are routinely dominated by regional voices within the planning and project selection processes. Further, most federal transportation administrations have only a small role in actual project construction, maintenance, or operation. If for no other reason, the uniquely federal perspective that guides Corps infrastructure processes from project conception through retirement distinguishes these processes and makes them worthy of further study.

THE US NAVIGATION SYSTEM

From its inception in 1775, the Corps has been responsible for navigation along coastal and inland waters. Throughout the 1800s, the Corps was active not only in establishing fortifications and mapping the American west, it also constructed lighthouses, piers and harbors, mapped navigation channels, and removed navigation barriers. Eventually, the Corps gained responsibility for the whole of the nation's water resources, a responsibility that is largely unchanged today (www.usace.army.mil/About/History/BriefHistoryoftheCorps/Beginnings.aspx).

The current inland system of 196 commercially active lock sites, with 241 lock chambers (multiple chambers at some sites), provides a navigation channel that is at minimum 2.7 meters deep on nearly 17,700 kilometers of inland and intracoastal waterways. This waterway network is plied by commercial towboats that push barges lashed together as tows; each barge is capable of holding 1300-1650 tons of cargo. A single tow of 15 barges, which is a common size, carries the freight cargo equivalent of 870 tractor-trailer trucks, making this a low-cost and fuel-efficient freight mode especially suited to bulk cargo that is not time-sensitive.

The inland and intracoastal waterway system that the Corps oversees is an integral, albeit largely unnoticed, part of the US freight transportation system (see Figure 1). This network handles about 560 million metric tons, and 400 billion ton-km, of domestic cargo movements annually—principally raw materials as well as liquid and bulk primary products such as coal, petroleum, chemicals, grain, processed metals, cement, sand, and gravel. It is the primary artery for more than half of the nation's grain and oilseed exports, for about 20 percent of the coal for utility plants, and for 22 percent of domestic petroleum movements. In addition, the US depends on shipping to Alaska, Hawaii, and Puerto Rico while transiting deep-sea regions, as domestic coastal shipments. From a national transportation perspective, it is a quiet mode that goes largely unnoticed.

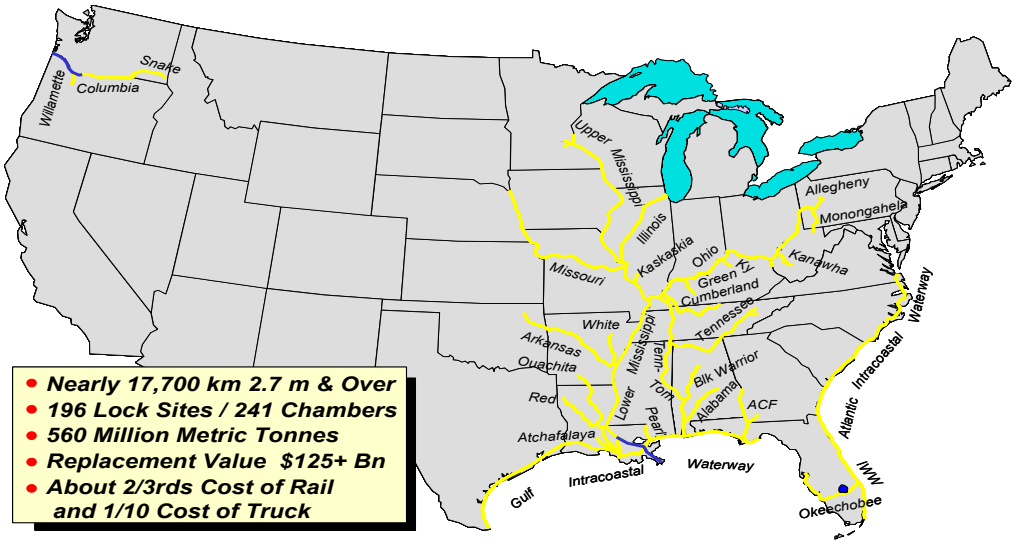

Figure 1: Map of the Inland River System

While the inland waterways represent vital trade corridors, the coastal navigation system, with its federal navigation channels, represents an entirely different network of coastal ports. These channels help vessels call at over 260 coastal and inland ports through over 275 navigation locks. In addition, the Corps supports navigation projects in deep-sea ports, including some of the largest ports in the world: Los Angeles/Long Beach, Houston, New York, and New Orleans. For both inland and coastal navigation, the federal government's responsibly is to support commercial traffic on the navigable waterways and ports of the United States. In practice, this means managing a diverse set of navigation infrastructures and activities, ranging from locks and dams to dredging to constructing and maintaining key navigation structures that ensure safe passage while supporting waterborne commerce.

THE CORPS PLANNING AND PROJECT APPROVAL PROCESS

In a Congressional Research Service report to Congress, a primer describes how the Corps is organized and how the project selection process works (Carter, 2006). Formally, the Corps has military and civilian responsibilities. On the civilian side, a military Chief of Engineers who reports to the Assistant Secretary of the Army for Civil Works is responsible for planning, constructing, operating, and maintaining a wide range of water resources projects. In the Corps' organization, projects are planned at the district level with approval required at the division and headquarters levels. (The Corps generally aligns district offices based on waterway systems, and not political boundaries, to ensure consistent oversight of a watershed.)

More recently, in addition to its traditional navigation system responsibilities, the Corps has acquired ancillary duties in areas such as environmental restoration of wetlands, municipal water and wastewater facilities, and disaster relief. The Corps also has authority to issue permits for private actions, such as building recreation docks, where such actions could affect wetlands or other waters.

Given any number of candidate projects and finite resources, the Corps must develop and follow project priorities in order to secure funding. The Corps uses a two-phase planning process to determine whether a project should receive federal funding and also informs congressional

decision-making. Historically, feasibility studies have been directed by the 1983 Principles and Guidelines. However, the Council on Environmental Quality issued proposed revisions in 2009 at the request of Congress (dels.nas.edy/Report/Review-Proposed-Revisions/13071). Under current guidance, the Corps must evaluate projects based on the Principles and Guidelines, but analysts have also been instructed to consider the proposed 2009 revision within their work. Projects can emanate from a variety of sources that includes local, regional, and state jurisdictions; industrial, recreational, and agricultural users, or constituencies concerned with freight transportation.

The Corps requires authorization and appropriations to initiate a study. This authority allows the Corps to commit resources to determine if it is in the best interest of the federal government to proceed with a more detailed investigation. If previous studies of similar proposals in the same geographic area exist, a new study may be authorized by a resolution from either the House Transportation and Infrastructure Committee or the Senate Environment and Public Works Committee. If not, Congress must pass an act to authorize work. The Water Resources Development Act is the vehicle through which this is done, and these Acts are passed biennially. After authorization, appropriations are received through annual Energy and Water Development Appropriations Acts. If a study determines that that the federal government (and those on whose behalf it acts) would benefit from the proposed action, the chief of engineers may sign a final recommendation for the project, commonly referred to as a *chief's report*. Once authorized, federal funds for project construction are sought through the annual Energy and Water Development bills.

The Corps District in which a proposed project is located ultimately is responsible for the conduct of necessary studies. In the case of more modest projects, in-house Corps staff members typically perform studies. However, for large scale projects, the responsible Corps District generally relies on expertise from one or more of the Corps centers of expertise, the Institute for Water Resources located in northern Virginia, or from outside experts, including academics, professional industry consultants, or other appropriate sources. Critical elements of the studies are also subject to well-defined internal and external technical review processes.

Using the example of a dredging project, the Corps not only must account for project influences at a local level, it also must consider its implications on the larger transportation system. Accordingly, the federal government must be able to demonstrate that national development goals will be served by developing specific channels and waterways. The determination of federal interest requires that most civil works projects adhere to the following six step planning process, which seeks to ensure transparency, efficiency, and equity in the project formulation and selection process. (The Corps' planning process is well documented at http://planning.usace.army.mil/toolbox/.)

Step 1. Problem Perception

The local community—whether it is a port, local business, or local governments—identifies a water resources problem that they cannot solve. These problems must be clearly defined and demonstrate that the federal government should support the study.

Step 2. Requires Federal Action

Local officials discuss the identified problem with the Corps of Engineers. If the project requires a study authorization, a request must be submitted to their local congressional representative. The congressional delegation proposes a study authorization to the Public Works Committees. If approved by Committee, the project is included in legislation, which must be

approved by the President of the United States if previous Corps studies do not exist on this specific problem.

Step 3. Study Problem and Report Preparation

The approved project is assigned to the Corps district office. Congress authorizes the Corps to conduct a Reconnaissance report. This report outlines various alternatives to the initial proposal and identifies cost-sharing components. Many Corps projects involve some local cost sharing that reflects a local or regional capture of project benefits through transfers of economic activity from other areas. However, every project also must provide benefits to the nation as a whole. This is the point where public review of the proposal and its alternatives is conducted formally through the Environmental Impact Statement (EIS).

Step 4. Report Review and Approval

The Corps division office reviews the district's work before submitting the report to the Washington Level Review Center. The final EIS is submitted to the US Environmental Protection Agency. The Chief of Engineers reviews the documents and considers comments from related groups and agencies. Next, the report is submitted to the Assistant Secretary of the Army (Civil Works), who transmits it to Congress once approved by the Office of Management and Budget.

Step 5. Congressional Authorization

The Chief of Engineer's report is sent on to the Committee on Public Works and Transportation in the House of Representatives and the Committee on Environmental and Public Works in the US Senate. The Civil Works budget is authorized through the Water Resources Development Act (WRDA).

Step 6. Project Implementation

The President's budget includes new projects based on the national priorities and the anticipation of design and specifications to allow construction contracts to be awarded. Budget recommendations include the ability of the local sponsor to provide their portion of the project's costs. Congress authorizes this through the annual Energy and Water Development Appropriates Act. A Local Cooperation Agreement (LCA) is signed, obligating non-federal local sponsors and the Corps of Engineers to work on developing the project as established by Congress and the Administration.

The same six-step process is used for all new construction projects across the United States. Once completed, the federal government maintains the resulting structure in perpetuity. Considering the planning for a new project, the maintenance decision framework remains fairly straightforward. The comparison of the Corps planning process is broader than other related agencies involved in transportation, as their projects require two different congressional authorizations. While critics argue that this may actually delay projects or result in the failure of approved projects to receive appropriations, the Corps' approach helps ensure any planning documents develop in a fairly transparent manner.

How long does the process take from the initial request to a chief's report? While the Corps does not generally record this information, one can assume that an average project will take seven to nine years from the initial reconnaissance study to a completed chief's report. Over that same period of time, the study will probably undergo two or three cost evaluations, adding more costs to the study's budget. While the Corps strives to complete its economic forecasts in a

timely manner, in practice much of the project determination timeline lies outside of the analyst's control. For example, projects can be delayed by conflicting guidance, project creep, data availability (especially concerning biological or environmental related estimates), and the skill of the research team. Finally, studies could be delayed by public comment, interagency review, or even Congressional oversight. In general, the overall process takes too long, which may restrict effective investment decisions.

Given these long delays, the Corps has begun improving the planning cycle. A memo from General Walsh calls for the Corps' process to work towards a 3x3x3 rule: The study should cost less than $3 million to complete, be developed in less than three years, have three levels of teaming oversight, and the main report be less than 100 pages (to fit into a three ring binder). This new guidance should not only ensure that projects are selected in a timely manner, but should also reduce the total project study costs. (More information on the Corps Planning Modernization process is available in the Planning Community Toolbox http://planning.usace.army.mil/toolbox/smart.cfm.)

FUNDING SOURCES

All funding for the Corps of Engineers comes from Congressional appropriations. However, the Corps primarily funds its navigation programs through two external trust funds: the Inland Waterway Trust Fund and the Harbor Maintenance Trust Fund.

The Inland Waterway Trust Fund, based on a per gallon tax on diesel fuel purchased by commercial towing companies, is generated to offset the costs of inland navigation projects for locks and dams. Collected revenues are held and invested within the Inland Waterway Trust Fund. These funds cover half of the related costs for inland navigation projects with the remaining funds coming from the general treasury through Congressional appropriations. The Waterway Trust Fund had a balance of $57.7 million at the end of Fiscal Year 2009, with an estimated $40 million that could be spent on new obligations.

In accordance with the Harbor Maintenance Trust Fund (HMTF), authorized in Water Resources Development Act (WRDA) 1986, taxes are levied based on the value of cargo arriving in US ports as well as the value of coastal shipments. The cargo is assessed at a rate of 0.125% of cargo value. The fees, collected only on inbound cargos, are held in the trust fund and used as match for dredging federal channels, as authorized by Congress. Any project authorized by the HMTF must have a local cost-sharing partner. The current formulas for local cost sharing of deep-sea ports projects (non-inland waterways) are related to the depth of the project. For projects under 20 feet, the split is 80 percent Federal, 20 percent local sponsor, with the local sponsor paying 10 percent upfront and the remaining 10 percent over time. For projects between 20-45 feet, the federal share drops to 65 percent, with the local sponsor paying 25 percent upfront and the remaining 10 percent later. Finally, for any project over 45 feet, the federal share falls to 40 percent, with the local sponsor covering 50 percent of the initial costs, with the remaining 10 percent repaid over time. Sponsor-provided Lands, Easements, Rights-of-Way, Relocations, and Dredge Material Disposal Sites (LERRD) can offset the 10 percent repayment feature partially or entirely. Also, the local sponsor must design a payment schedule prior to the project's initial construction. (The greater-than 45 feet project dimension has been a contentious issue for many ports attempting to secure additional depth in anticipating of the expansion of the Panama Canal.)

2. BENEFIT-COST ANALYSIS: A PROCESS HISTORY

A FOUNDATION FOR BENEFIT-COST ANALYSIS

The concept of benefit-cost analysis was in its infancy when the Corps began using the technique to inform decision-making for water resources projects. Among others, the French engineer Jules Dupuit was a pioneer on the topic (www.sjsu.edu/faculty/watkins/cba.htm). In an 1844 volume, Dupuit focused on the proper toll to charge in the operation of a bridge. He explored concepts that later became known as *consumer's surplus*, *willingness to pay*, and *diminishing marginal utility*. Dupuit wrote (Hanley, 1993):

> For an increase or decrease of utility to take place, there must be, provided there is no change in quality, a decrease or increase in the cost of production. When there is merely a change in the market price the consumer gains what the producer loses or vice versa.

Thus, engineer Dupuit linked welfare and cost.

In 1898 the economist Vilfredo Pareto laid the foundation for modern welfare economics by asserting that an economic outcome is desirable if at least one person gains while no person loses. But Pareto's axiom is not useful for practical application because of differences in personal preferences. In the late 1930's Nickolas Kaldor, with the concurrence of Sir John Hicks, proposed that the difficulty in making interpersonal comparisons of utility was irrelevant. Instead, Kaldor argued that a project is efficient assuming that any monetary gain is greater than its cost. This became the Kaldor-Hicks criterion and is the foundation for modern benefit-cost analysis (Zerbe, 2006).

EARLY PARALLELS IN PRIVATE-SECTOR TRANSPORTATION ANALYSIS

While public sector planners focused on public welfare, the private sector focused on a stream of current and future profits. However, transportation planning for either purpose requires optimal network investments based on largely the same set of parameters. Thus, the parallels between these processes were evident in the latter half of the nineteenth century.

During the last quarter of that century, private firms (often with public sector assistance) completed the development of the US railway network that still exists in the twenty-first century. Engineering texts from that period devote considerable attention to topics that remain relevant today regardless of whether infrastructure investments are undertaken by the private sector for profit or by the public sector to serve a public need. Some examples are

- Associating transport capacity with various construction alternatives;
- Projecting traffic and resulting revenues under the same construction alternatives;
- Considering the rehabilitation versus the replacement of existing facilities;
- Weighing the value of currently foregone capital requirements against future expansion costs;
- Considering the impact of variations in present and future interest rates; and
- The impact of individual component construction on greater network (system) performance.

Moreover, while most associated guidance is related to maximizing the profits directly attributable to railroad construction, operation, and maintenance, broader economic influences of

the sort currently treated under economic development motives are carefully noted. For example, consider the following text drawn from Wellington in 1887:

> Neither does it follow that the deciding motive is direct pecuniary profit; for the line may be of great value to the investors and the public, and yet never pay such profit. In fact, the railway system of the world, taken as a whole, and especially that of the United States, has been only very moderately profitable in any direct form; owing not so much to mistakes of judgment pure and simple, as to the very large proportion of lines which have been built simply to increase the value of land, to afford local transportation facilities, to bring traffic to the main line, and similar purposes. Yet the resulting gain to the community, from these indirect advantages alone, has been vast beyond computation; so much so that, although the lines on which investors have lost money have been many, there have been few or none which have involved a positive loss to the community as a whole.

Clearly, by the dawning of the twentieth century, the use of sound economic principles in the evaluation of both public works and private infrastructure investments had become a dominant practice in US transportation planning.

CORPS OF ENGINEER ECONOMIC PRACTICES, 1900-1983

Almost four decades before Kaldor and Hicks, as early as the Rivers and Harbors Act was passed in 1902, the Corps was using benefit-cost analysis (Hammond, 1966). This Act required the Board of Engineers for Rivers and Harbors, a group established by the Corps, to certify a project as beneficial before it was undertaken. Theodore Porter writes about the early Corps of Engineers work in the book *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life.* He notes that before the Corps began using benefit-cost analysis to make decisions on project investments, these decisions were made in a near-ad hoc fashion. Congress felt that the Corps was a prestigious organization that with ample skills to quantify project benefits and costs and that these skills could be used to assist in their evaluation marginal projects. In this role, the Corps rejected over half of the proposed projects, generally because they lacked economic justification. By the 1920s projects approved for construction were required to have forecast benefits in excess of costs. Porter adds that through the 1930s, the Corps recommendations for construction generally were accepted without question.

The construction plans for a system of high dams on the Tennessee River are an example of early Corps work. In a 1930 study discussed in *A History of Navigation on the Tennessee River System*, the Corps proposed that seven high dams be constructed, in addition to the Wilson and Hales Bar dams on the Tennessee River between Knoxville and the river's mouth. Interestingly, the methodology used by the Corps in this early study is similar to the basic methodology used by the Corps today (Secretary of War, 1930). In this early study, the feasibility of construction was based on the combined benefits of navigation, flood control, and hydropower generation compared to the cost of the projects and the resulting annual charges, including fixed charges and operation costs. On the proposed 652-mile navigation channel, the annual benefit-cost ratio in 1926 was estimated to be 4.8 and was projected to rise to 12.4 by 1950. There is no mention of the discounting of monetary values in the Corp's analysis. Otherwise, the methodology was strikingly similar to that used in current studies.

In 1936, the Flood Control Act was passed mandating the continuance of the Corps' existing practice of using benefit-cost analysis in project evaluation. Under this act, Congress could not fund construction programs that had not been approved by the Corps. The Corp's analyses eliminated many projects with poor benefit-cost ratios (Porter, 1995). In fact, absent a challenge by a powerful opponent, the Corps analyses were "… generally accepted with no more

authority than its own reputation" (Overton, 1938). The 1936 Act also established the notion of benefit-cost analysis in flood control activities and mandated that they be pursued, "if the benefits to whomsoever they may accrue are in excess of the estimated costs, and if the lives and social security of people are otherwise not adversely affected (U.S. Natural Resources Board, 1934)."

During the Great Depression, benefit-cost analyses, based strictly on monetary measures of costs and benefits, were thought by some to underestimate the benefits of public works as a means of diminishing unemployment. During this period, the Water Resources Board called for a study of "intangible factors" and for a revision of the cost estimation technique (U.S. Natural Resources Board). No new techniques were proposed, however, and it seems that individual agencies were encouraged to seek out ways to estimate benefits more liberally. In this way, the benefit-cost ratios for desired projects were made more favorable as the projects entered Congressional debate (Hammond, 1966).

After 1940, the Corps had less powerful constituents and therefore was challenged successfully by more powerful opponents including utilities, groups with shipping interests, and federal agencies such as the Bureau of Reclamation and the Department of Agriculture. For example, the missions of the Corps and Agriculture were not necessarily in conflict, but the Corps favored downstream flood control while the upstream residents complained about being flooded by downstream projects on occasion and being deprived of flood control services themselves. The Department of Agriculture had its own benefit-cost analysis techniques that treated downstream structures less generously that the Corps, and thus did not produce results compatible with the Corps' work (Porter, 1995).

As early as 1943, there was a perceived need to standardize agency benefit-cost practices. Hammond writes that, "… in 1946, perhaps embarrassed by the variety of agency practices that were revealed, the Federal Inter-Agency River Basin Committee appointed a Sub-Committee on Benefits and Costs 'for the purpose of formulating mutually acceptable principles and procedures.'" The Corps, the Departments of the Interior, Agriculture, and Commerce, and the Federal Power Commission comprised this committee. The Department of Health, Education and Welfare was added in 1948 after passage of the Water Pollution Control and Act of 1948.The committee met until May, 1950 before a final report requested by the President's Water Quality Resources Commission was completed (Sub-committee on Benefits and Costs, 1950). According to Hammond, "(t)his document, the so-called *Green Book*, has shaped official thinking ever since; any amendments have touched detail rather than principle."

The *Green Book* was the first major attempt to provide implementation guidance for the 1936 Flood Control Act that required benefit-cost analysis in the implementation of federal water control projects. Powers notes that the objective of benefit-cost analysis is to maximize general economic welfare and economic efficiency and should do this with respect to both market and non-market factors. Thus, the *Green Book* narrowed the objective of benefit-cost analysis to economic welfare and economic efficiency but defined these objectives broadly in terms of acceptable effects (Powers, 2003).

While implementing the *Green Book* methodology in benefit-cost analysis was voluntary, many procedures were incorporated into a Bureau of the Budget document (currently the Office of Management and Budget) "Budget Circular A-47." Powers notes that, except for unusual cases,

> … a project's estimated benefits must exceed its estimated costs. Throughout the 1950s, the Bureau of the Budget would not approve Corps projects that did not have a benefit-cost ratio, in terms of monetized benefits and costs, of at least 1.0. Although Circular A-47 states that benefits

> and costs should be estimated in monetary terms or in the most quantitative terms possible, a benefit-cost ratio only includes values measured in dollars. Since monetization of non-market benefits and costs can be difficult and is often controversial, the Corps interpretation Circular A-47 appeared to emphasize market over non-market benefits and costs.

It appears that the Green book's principle of maximizing the difference between benefits and costs rather than maximizing benefit-cost ratios was dropped in the transition to Budget Circular A-47. In 1960, Hirshleifer, DeHaven, and Milliman pointed out the fallacy of maximizing net returns at the expense of benefit-cost ratios (Hirshleifer, 1960).

In 1962, the Senate Select Committee on Water Resources recommended that the Kennedy Administration further revise the guidance for water projects and planning as laid out in the document *Policies, Standards and Procedures in the Formulation, Evaluation and Review of Plans for Use and Development of Water and Related Land Resources* (P&S). The 1962 regulations required the strict use of benefit-cost analysis to more generally provide the "best use, or combination of uses, of water and related land resources to meet all foreseeable short or long-term needs." Senate Document 97 suggested that the Corps concentrate on multiple objects in water projects such as economic development, preservation and the impact on people (Shen, 1973).

In 1968, the Water Resources Council (now inactive) began the process of rewriting the mandatory guidelines established in Senate Document 97. These proposed *Principles and Standards* (P&S) would replace Senate Document 97 with the Corps assessment of " ... a project's benefits and costs in terms of national economic development; quality of the environment; and regional development and social factors." Furthermore, it made clear that national economic efficiency should no longer be considered the primary objective (Powers, 2003)." This version of the P&S was never implemented, but a revised version was published for public comments (36 Federal Register, 1971). A further revised version, focusing on national economic development benefits, took effect in 1973 (38 Federal Register, 1973).

In 1974, the first Water Resources Development Act was passed, and under section 80(c) of WRDA 1974, there was authorization to revise the P&S (instituted in 1973) with a concentration on interest rates, multipurpose project objectives, and cost-sharing. A key issue was that the 1974 guidance mandated four **co-equal** accounts: national economic development, environmental quality, regional development, and social factors. Powers notes that this accounting system was never accepted during legislative and executive debate over water policy (Congressional Research Service, 2009).

President Reagan approved the *Principles and Guidelines* in 1983 that replaced the P&S that had been repealed by the Water Resources Council in September 1982. The Principles and Guidelines remains in effect although in the Water Resources Development Act of 2007 Congress instructed the Secretary of the Army to develop a new set of Principles and Guidelines for the Corps. The Principles and Guidelines is similar to the P&S in that the document contains four objective areas: National Economic Development (NED), Regional Economic Development (RED), Environmental Quality (EQ), and Other Societal Effects (OSE). The difference, though, is that the Principles and Guidelines does not weigh each account equally, rather the NED account is the only mandatory account used to evaluate federal water projects. In section II of Chapter I section (a), the federal objective is laid out:

> The Federal objective of water and related land resources planning is to contribute to national economic development consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements.

> In plan formulation, "(t)he NED account is the only required account. Other information that is required by law or that will have a material bearing on the decision making process should be included in the other accounts (EQ, RED, OSE) or in some other appropriate format used to organize information on effects."

1983 TO THE PRESENT

The U.S Army Corps of Engineers (USACE) continued its past operating practices for nearly a decade after the passage of legislation mandating use of the Principal and Guidelines and the Inland Waterways Trust Fund. This fund (news.business.vlex.com) was

> … established by the Treasury in fiscal year 1984, pursuant to section 203 of the Inland Waterways Revenue Act of 1978 and continued pursuant to section 1405 of the Water Resources Development Act of 1986. Under 26 US Code 9506(b), amounts from taxes on fuel used in commercial transportation on inland waterways, as determined by the Secretary of the Treasury, are appropriated to the trust fund. The Secretary of the Treasury invests in interest-bearing obligations of the US that portion of the trust fund, in his judgment, not required to meet current withdrawals. The Inland Waterways Revenue Act of 1978 provides that amounts in the trust fund shall be available as provided, by appropriations acts, for construction and rehabilitation expenditures for navigation on the inland and intracoastal waterways of the US described in 33 US Code 1804.

These amounts are transferred quarterly from the general fund based on estimates made by the secretary, subject to adjustments in later transfers to the amounts of actual tax receipts. Currently, the diesel fuel tax stands at 20 cents per gallon which, when matched by appropriations from the Treasury, operates to fund inland navigation major rehabilitation and new lock construction projects.

During this period, the USACE concentrated its inland navigation efforts on construction of the controversial Tennessee-Tombigbee Waterway (TTWW), which was completed in 1984 at a cost of $2 billion. After its completion, the Corps turned to several major lock construction projects on the Ohio River and tributaries that consumed virtually all of the Trust Fund monies. In the middle 1990's the St. Louis District of the Corps, using the Tennessee Valley Authority (TVA) as a major contractor, began to examine the feasibility of navigation improvements on the upper Mississippi and Illinois Rivers. TVA had performed the transportation rate analysis on the Ohio River projects, on contract to the Huntington District of the USACE, and the St. Louis requested their services based on the success the of the Huntington District in their lock feasibility studies. Not surprisingly, farmers, industry representatives, and political advocates from the upper Mississippi basin were anxious to see future Trust Fund receipts spent on the Mississippi River system given that diesel fuel taxes were being paid for towboat operation on their river system.

In the upper Mississippi studies, TVA rate analysts estimated modal transportation rates that were used as inputs to Corps of Engineer's lock capacity models wherein tows remained on the river in simulation exercises until congestion, brought on by assumed traffic growth into locks of fixed capacity, raised transportation rates sufficiently for traffic to shift modes to the next least costly alternative, which was generally rail transportation. These models, typically built by engineers when computational capacity was limited, assumed a perfectly inelastic response to rising barge transportation costs. Under such scenarios, waterway traffic diverts to the next most attractive mode when the barge rate for the waterborne shipments is marginally greater than the alternative transport rate. This very restrictive modeling approach is inconsistent with observed shipper behaviors and produces estimates of navigation project benefits that are, therefore, excessive.

Whistle Blowing. In 2000, a Corps economist working on the upper Mississippi River navigation improvement study filed a 44-page affidavit alleging that he was removed from his position for disagreeing with senior managers regarding the study's traffic forecast (Randall, 2000). Dr. Sweeney laid out his position in a paper later published by the Corps' Navigation Economic Technologies (NETS) program (Sweeney, 2005). Sweeney also took direct aim at the demand modeling scenarios described above, calling the resulting treatment of shipper demands an "unrealistic 'all or nothing' shipper's modal choice decision in the model framework." If one assumes that shipper volumes are sensitive to rising transportation rates as throughout the rates' rise toward the alternative price, the resulting calculations produce very different results in which system benefits are smaller.

The National Academies of Science Review. In addition to the methodological economic issues raised by Dr. Sweeney, there was pressure on the Corps from Congress to address navigation improvements and "the degradation of the ecosystem that has accompanied seventy years of locks and dams (National Research Council, 2004)." The first Interim Report for the Restructured Study appeared in July 2002. Sweeney's ESSENCE model was used in this study as a tool to estimate system benefits. In March 2003, the Corps requested that the National Academy of Science (NAS) convene a committee to review the restructured study. In the NAS study, the panel urged to Corps to develop credible economic models, develop credible traffic forecasts, implement small-scale measures, and restore natural processes ("National Academy of Sciences Report Blasts Corps Mississippi River Study").

The Corps responded to the NAS review with several programs: the Planning Models Improvement Program, external peer review, and the aforementioned NETS program. Each of these is described briefly.

Planning Models Improvement Program. The Planning Models Improvement Program (PMIP) was established in 2003 to assess the state of planning models in the Corps and to make recommendations to assure that high quality methods and tools are available to enable informed decisions on investments in the nation's water resources infrastructure and natural environment. On May 31, 2005, the Department of the Army issued Circular 1105-2-407 that establishes the process and requirements for certification of planning models. As part of the certification process, expertise from inside and outside the Corps is required in the development or revise of affected models.

Peer Review Processes. Engineering circulars are also used to establish "the appropriate level and independent review and detailed requirements for review documentation and dissemination." Circular 1105-2-410 provides procedures for assuring the "quality and credibility" of Corps decisions through independent review. This process began in May of 2005 with the publication of EC 1105-2-408 "Peer Review of Decisions Documents."

The NETS Program. The NETS program was established to provide the Corps with independently verified, objective economic models, tools and techniques for evaluation current and future needs. The program resides at the Corps' Institute for Water Resources and is currently relatively inactive. Nonetheless, in the years between 2001 and 2010, the program employed a variety of highly acclaimed academic economists and transportation experts who developed a wide array of sophisticated economic tools and techniques. Many of the NETS innovations were subsequently incorporated into Corps planning models through their inclusion in the Planning Models Improvement Program (PMIP).

Proposed Revisions to the Principles and Guidelines. In the 2007 Water Resources Development Act, Section 2031, Congress instructed the Secretary of the Army to develop a new

set of governing principles and application guidance for the use in the evaluation of water resource projects. Further, President Obama in Executive Order 13563, *Improving Regulation and Regulatory Review*, laid out the parity in the national objectives of public health, welfare, safety, and the environment while promoting economic growth, innovation, competitiveness and job creation. To this end, the Obama Administration had planned to expand the new Principles and Guidelines to all federal agencies that undertake water projects and not just the four federal agencies that are subject to the current Principles and Guidelines. The Council on Environmental Quality completed a draft of the Principles and Standards (the first chapter of the Principles and Guidelines) and includes four major proposals to modernize the Principles and Guidelines (www.whitehouse.gov/administration/eop/ceq/iniatives/PandG):

- **Achieving Co-Equal Goals**. The Administration's proposal reiterates that federal water resources planning and development should both protect and restore the environment and improve the economic well being of the nation for present and future generations. While the 1983 standards emphasized economic development alone, the new approach calls for development of water resources projects based on sound science that maximize net national economic, environmental, and social benefits.

- **Considering Monetary and Non-Monetary Benefits**. The revised Principles and Standards shift away from the earlier approach to project selection. Specifically, the revised version will consider both monetary and no-monetary benefits to justify and select a project that has the greatest net benefits-regardless of whether those benefits are monetary or non-monetary.

- **Avoiding the Unwise use of Floodplains**. The new Principles and Standards represent significant progress in the way we manage our floodplain resources. The decision to modify water resources and floodplains will be based on evaluations of the services gained and lost by such an action. Only those actions that provide a net benefit will be further pursued or recommended for construction. For the first time such evaluations must give and equal consideration to nonstructural approaches that can solve the flooding problem without adversely impacting floodplain functions.

- **Increasing Transparency and "Good Government" Results.** The revised Principles and Standards are intended to promote the transparency of the planning and implementation process for water resource development projects in this country. The proposed changes were made to deliver "good government results" for the American people. It is expected that the use of best science, peer review, and full transparency will ensure that projects undergo a more rigorous study process, which should inform authorization and funding decisions.

Further, it is expected that each agency will devise their own "Procedures" to outline how the new Principles and Guidelines apply to their mission.

The revised P&G were released by the Council on Environmental Quality in 2009 and were reviewed by the National Academy of Sciences in 2010. In a very critical review, the Academy found fault with the revised Guidelines in four key findings (deis/nas.edu/Report/Review-Proposed-Revisions/13071):

- General planning principles, steps and concepts, as revised could be part of planning process. However, the principles are abstract, and inconsistent, and the proposed planning steps are confusing and do not support practical implementation. The proposed revisions

thus have only limited value as policy guidance and are inadequate as an operational or "decision," document. As the Council on Environmental Quality proceeds with further revisions and provided more specific program guidance, these applications may become clearer.

- The distinctions among objectives, principles, and standards in the proposed revisions are not clear and the relationship among them is not maintained through the document.
- The proposed revisions carry over concepts, advice, and language from historical practices that are not fully consistent with contemporary best practices in science and economics.
- The proposed revisions will apply to the traditional federal water project construction agencies: the Bureau of Reclamation, USACE, TVA, and the U.S. Bureau of Agriculture (Natural Resources Conservation Service). Other federal agencies that the document will apply to, as well as specific programs, studies, and projects, are not clear.

3. CURRENT CORPS PLANNING AND ANALYSIS PROCESSES

THE BROAD DECISION MAKING STRUCTURE

The complexities introduced into the Corps of Engineers' study process by the inclusion of additional considerations and as a product of methodological scrutiny have resulted in lengthy studies. While assigning an average duration is not possible, it is not unusual these days for the preparation of Corps studies to span decades. Indeed, the upper Mississippi study that was at the center of so much public controversy began in the early 1990s and has yet to reach a definitive conclusion regarding the lock expansions and auxiliary chamber construction that prompted original proposals. Many other studies have been similarly delayed, resulting in a need to reproduce research efforts deemed to be "stale." Understandably, the process frustrates system users who are expecting projects to be delivered as authorized.

Regardless of study scale, topic, or duration, the heart of the Corps' decision-making process is the calculation of benefit-cost ratios that compare the incremental benefits and costs of *with project* scenarios to the benefits and costs under the status quo or what the Corps refers to as *without project* conditions. Cost calculations focus on the present value of construction costs and incremental differences in operating costs over the proposed project's life. Benefits are restricted to National Economic Development (NED) benefits, which generally represent net economic efficiency gains and exclude simple economic transfers between economic agents. This latter class of project benefits is referred to as Regional Economic Development or RED benefits. (The Institute for Water Resources Primer provides a good introduction into the Calculation of NED benefits, http://www.iwr.usace.army.mil/docs/iwrreports/iwrreport_09-R-3.pdf.)

QUANTIFYING BENEFITS AND COSTS UNDER THE PRINCIPLES AND GUIDELINES

To reduce the subjectivity in what can be a very controversial process, the Principles and Guidelines mandate the set of benefits the NED account may include:

> Beneficial effects in the NED account are increases in the economic value of the national output of goods and services from a plan; the value of output resulting from external economies caused by a plan; and the value associated with the use of otherwise unemployed or under-employed labor resources.

The general measurement standard in the Principles and Guidelines states

> The general measurement standard of the value of goods and services is defined as the willingness of users to pay for each increment of output from a plan. Such a value would be obtained if the "seller" of the output were able to apply a variable unit price and charge each user an individual price to capture the full value of the output to the user. Since it is not possible in most instances for the planner to measure the actual demand situation, four alternative techniques can be used to obtain an estimate of the total value the output of a plan: willingness to pay based on actual or simulated market price; change in net income; cost of the most likely alternative; and administratively established values.

The categories of goods and services for which NED analyses can be undertaken include

- Municipal and industrial water supply
- Agricultural floodwater, erosion and sedimentation reduction
- Agricultural drainage
- Agricultural irrigation

- Urban flood damage reduction
- Power (hydropower)
- Transportation (inland navigation)
- Transportation (deep draft navigation)
- Recreation
- Commercial fishing

The benefit evaluation procedure in each of these categories is specific. For example, in the inland water transportation category, the NED benefit is the reduction in the value of the resources required to transport commodities. To measure this reduction, the Principles and Guidelines establishes four benefit sub-categories:

- Cost reduction benefit-same origin, same destination where the resources will be reduced for productive use elsewhere in the economy.
- Cost reductions incurred from trip delays where lock size can be increased or congestion fees can be imposed.
- Shift of mode benefit (same origin-destination; different mode). The benefit to the national economy is the savings in resources from not having to use a more costly mode.
- New movement benefit. This benefit applies if a commodity or additional quantities of a commodity would be transported only because lowered transportation charge with the project.

Developing measures within these categories requires the treatment of several issues:

Rates Versus Costs. For inland transportation feasibility studies, the Principles and Guidelines require that transportation rates be used in lieu of cost for shift of mode benefits. The document states that there are two reasons for this mandate. First, it is more difficult to compute long-run marginal costs for rail movements on the basis of cost studies rather than determining the rates at which commodity actually moves. Also, rates charged determine the distribution of modal traffic.

Rail and Highway Capacity. In the *without project* condition, the alternative modes—rail, highway and pipeline—are assumed to have sufficient capacity such that traffic can be moved at current rates. For Deep Draft Navigation projects, guidance exists regarding multiport studies that assess any changes to traffic patterns, and thus project needs. Although a requirement when considering deep draft navigation projects, there exists no explicit or consistent application of the methodology for determining the type of multiport analysis and the data (research requirements) necessary to develop adequate information to support decision makers. Port competitiveness and market reach have been researched in academic papers and port planning reports. These studies, while providing information on traffic patterns and potentially competitive flows, present some guidance for developing a framework to examine project benefits from a national level but to date multiport studies are not routinely performed.

Real Versus Nominal Costs and Benefits. The Principles and Guidelines require that the analyses be expressed in terms of real rather than nominal dollars:

> The general level of prices for outputs and inputs prevailing during or immediately preceding the period of planning is to be used for the entire period of analysis. In the case of agricultural planning, normalized prices prepared by the Department of Agriculture should be used.

Powers notes that "economists, environmentalists and fiscal conservatives" have criticized the Principles and Guidelines for the mandated use of data expressed in real terms.

> Calculating real (constant) dollar values attributable to some of the aforementioned benefits and costs, varies in difficulty. Whenever possible, the Corps values benefits and costs using market prices for the good or service. For example, the value of protecting structures from flood damage is based on the structures' market value. However the valuation process becomes more challenging and controversial as the good in question becomes further removed from one that is traded in an actual market or will be traded in the more distant future. For example, it is more difficult to value a project's recreational benefits, or environmental costs, than to value its electricity benefits.

Discounting Benefits and Costs. The Principles and Guidelines are vague on the value of the discount rate that should be used in water project studies. Section 1.4.11 mandates use of the "discount rate established annually for the formulation and economic evaluation of plans for water and related land use projects." However, it does not indicate where this rate is to be found. In practice, the Corps (and other agencies to which the Principles and Guidelines apply) rely on the discount rate established under the Water Resources Act of 1974 (WRDA 1974) that establishes a rate based on "the average rate of interest payable by the Treasury on interest-bearing marketable securities of the United States ..." This basic discount rate definition began with the 1950 publication of the *Green Book*. At various times it has included or excluded securities with less than 15 years to maturity and it sometimes has had annual changes capped at 0.25 percent per year, but the basic definition is unchanged. Alternatively, in the case of non-waterway projects benefits and costs are discounted based on the rate established by OMB Circular A-94.

Sound economic practice dictates that both benefits and costs that accrue in the future be discounted to determine the present value of revenue and expenditure streams. While simple to describe, applying this notion can quickly become exasperating. At present, proposed water and non-water infrastructure investments often are evaluated based on methodologies that treat the issue of discounting differently. Under currently observed economic conditions (low expected inflation), this does not produce any significant bias in resulting benefit-cost ratios. Nonetheless, three points are clear: (1) the current Corps methodology runs contrary to accepted economics and the broader guidance provided by the Office of Management and Budget (OMB), (2) any consistency between current Corps discounting values and outcomes of the OMB-prescribed discounting methodology is largely coincidental, and (3) any period of sustained expected inflation is likely to bias analytical results inappropriately to the detriment of water-related infrastructure investments.

The discount rate used under the Principles and Guidelines is a "nominal" rate. The average Treasury rates that are its foundation include both a real return to security holders *and* an expected rate of inflation. Under current processes, this discount rate is then applied to "real" values that have already been adjusted to reflect the impacts of expected inflation. All else being equal, this necessarily results in a systematic understatement of the present value of future benefits or costs and (assuming that most costs occur early in project cycles) the calculation of benefit-cost ratios that are systematically biased downward.

The application of a nominal discount rate to an inter-temporal stream of monetary values is clearly wrong and the resulting downward bias in calculated values would likely disadvantage

water-related projects relative to non-water candidates except that the discounting process outlined under OMB Circular A-94 has also encountered difficulties in application.

The original 1992 OMB circular establishes a real base discount rate of seven percent, stating, "This rate approximates the marginal pretax rate of return on an average investment in the private sector in recent years." This rate, while ostensibly reasonable, is more than two times the traditionally assumed real interest rate of three percent and currently 50 percent greater than readily observable nominal interest rates. As a consequence, 2003 revisions to A-94 (via OMB Circular A-4) allow the use of a three percent real discount rate in some and otherwise instruct the use of three percent and seven percent as analytical bounds. The result has been the use of real discount rates with an effective average of between three and five percent—rates that are only one or two percent lower than the nominal rates obtained under the applications of the Principles and Guidelines.

The current similarity in the discount rates used to apply the Principles and Guidelines and the corresponding rates used in accordance with OMB Circular A-94 is purely coincidental. The OMB rate is a real rate that is invariant to changes in expected inflation. The rate used by the Corps is a nominal rate that does vary directly with anticipated inflation. To understand the potential influence of this distinction on the decision-making process, one need only consider that the Corps discount rates for 1987 – 1989 averaged nearly nine percent – a level roughly double the average current real discount rate applied under OMB A-94. Again, assuming that most costs are incurred early and that benefits occur later with the growth in use, this difference in discounting could produce very different benefit-cost ratios for, otherwise, identical projects. One Corps employee suggested that guidance should simply pick two rates, e.g., 3 or 10 percent, and simply use that to determine project costs.

THE TREATMENT OF EXTERNALITIES

Transportation services provide benefits to those who purchase them; they also routinely benefit other people whose exposure to transportation activities is more incidental. Formally, impacts (good or bad) to individuals who are not direct transaction participants are referred to as *externalities*. Particularly, in the case of commercial navigation where freight movements are less disruptive than many transportation alternatives, Corps activities often generate a wide array of external benefits or at least help mitigate more extensive external costs. Water transportation generally is segregated from other activity so that most populations experience very few related effects (collisions, other accidents or congestion, view-shed incursions, noise, pollution, etc.). Moreover, water transport often involves the consumption of less fuel per ton-mile, so that fuel consumption and related pollutant emissions are generally less than for other freight modes.

Regardless of the source, external benefits (or reduced external costs) reflect net efficiency gains and so are similar to other NED benefits. Since 1983, the Principles and Guidelines have allowed the consideration of externalities within the project evaluation process. However, their values are seldom included directly as NED benefits and therefore do not typically enter into benefit-cost calculations.

Measuring the external influences associated with shifting waterway traffic to land transportation began with the work of William Newstrand at the Minnesota Department of Transportation in 1991. In his study, *Environmental Impact of a Modal Shift*, Newstrand examined the impacts of several hypothetical cargo shipments as they shifted from barge to rail or truck transportation. While he did not attempt to monetize the impact of the diversion, the physical impacts were measured with the best data available at the time for fuel usage, emissions, accidents, and congestion.

Newstrand's work influenced economists at TVA who, in March of 1996, produced the *Final Environmental Impact Statement, Chickamauga Dam – Navigation Project*. Within that work, Newstrand's data were used to estimate the impact of traffic diversions from the upper Tennessee River to highways in the area, especially I-75 through Chattanooga. Later, TVA was offered the chance to revisit this work so that it could be made compliant with the Principles and Guidelines. The revised TVA study was based on a variety of methodological improvements including segment-specific barge fuel calculations based on a fully disaggregated barge costing model. Carrier-specific railroad fuel estimates are based on data provided by the Association of American Railroads. The combined valuation of crashes, incidents, and congestion was used by the Corps to establish "without" project conditions but was not used in the benefits calculation.

This began a decade long set of externalities-related interactions between TVA and the Corps. By 2006, TVA had produced "nonstandard" benefits calculations for three feasibility studies—Soo Lock, Chickamauga Lock and the Red River in southeast Arkansas. The Red River study involved extension of navigation from Shreveport, Louisiana to Texarkana, Texas and the associated reconstruction of several bridges. In a later study, also prepared for the Huntington District of the Corps, TVA examined the impact on the Pittsburgh area given short term and intermediate term closures of at Emsworth, Dashields, or Montgomery (EDM) Locks on the upper Ohio River. These benefits were earlier denied for inclusion in NED benefits calculation in the Chickamauga and Soo Locks studies. The position of the Corps was that "…policies and national procedures had not been established" regarding inclusion of nonstandard benefits in these studies.

At issue were TVA benefit estimates related to

- Air emission reductions and related health benefits
- Reduced road travel times
- Reduction in road pavement and repair costs
- Reduced incidents on roadways.

It is clear that the Corps Circular 1105-2-409 requires that planning studies consider the full range of benefits categories of the 1982 Principles and Guidelines accounts: National Economic Development (NED), Environmental Quality (EQ), Regional Economic Development (RED), and other Social Effects (OSE). According to Headquarters directives the

> …planning reports will include a full discussion and display of the beneficial and adverse effects of each plan and a comparison of costs and effects among plans as well as cumulative effects. As an example the guidance indicates that the evaluation of inland navigation improvements should not only address effects on transportation savings but also security, safety and environmental advantages or disadvantages with respect to other modes of transport.

In 2006, the Corps sought to determine which of the four categories of nonstandard benefits was ready for inclusion into benefits calculations without double counting or requiring further research. Three other questions were also posed: (1) should traditional shipper savings benefits be augmented with the externality benefits in benefit-cost calculations, (2) how should the externality estimates be used in plan evaluation and selection, and (3) should externality calculations be mandatory for all projects or be estimated at the choice of the Districts.

At that time, the externality category chosen by the Corps for inclusion in benefits calculation was reduced road travel times. In the Red River study, this category had the "least policy and theory concerns" but also had the largest value of the four candidate areas. The

current position of the Corps regarding the inclusion of congestion benefits is summarized in the February 2006 memorandum:

> The Corps should continue to formulate plans in navigation studies in accordance with the primary mission of navigation. Optimization should be based on the traditional mission-related benefits to determine the NED plan. In the case of a navigation study, the basis would be the standard navigation benefits enumerated and described in the P&G. The non-standard benefits (externalities) mentioned, where measurable, would be displayed in the appropriate account (NED, EQ, RED, and OSE). Changes in land side travel times would be displayed as an NED indirect effect. Navigation studies focus on alternatives that improve the efficiency of commodity movements on the waterways. Any effect on road conditions or traffic as a result of navigation improvements is an *indirect* effect. These effects may be positive (benefits) or negative (costs). Road effects resulting from navigation projects, while measurable as NED effects, must be considered indirect project effects. These indirect NED effects cannot be used in project formulation, scaling, or NED plan selection, nor should they be used to justify a project on an NED basis. They can only be claimed as NED benefits on economically-justified projects, and only in this case used to calculate the BCR."

Here the P&G refers to the Principles and Guidelines mentioned above, and BCR refers to the benefit-cost ratio.

4. OTHER AGENCY PROCESSES

The Corps is, by no means, the only public entity charged with planning, evaluating, constructing, and maintaining critical transportation infrastructures. USDOT develops and supports facilities across nearly all transport modes and sets guidance for other transportation projects that receive federal funding or oversight. In the case of USDOT, the goals and corresponding processes are, on their face, the same as those that guide the Corps. States, however, frequently have a much different perspective so that, even though there are apparent similarities in language and measurement, both process goals and applications vary significantly from the federal process.

NON-CORPS FEDERAL TRANSPORTATION PROJECTS

Figure 2 depicts the basic relationship between federal and state transportation planners, including a rough representation of revenue flows. Setting aside federal funding for state and local initiatives, the general goal of all federal transportation investments is the same—to increase the efficiency of the national transport system without regard to region-specific impacts. Specifically, with regard to Corps-related navigation projects, the Principles and Guidelines state:

> …contributions to national economic development (NED) are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and rest of the Nation. Contributions to NED include increases in the net value of those goods and services that are marketed, and also of those that may not be marketed.

While the specific language refers to "economic development benefits," the associated definition equates precisely to economic efficiency gains as typically described in the economic literature. Similar language can be found in Federal Aviation Administration (FAA) and Federal Highway Administration (FHWA) materials.

Importantly, however, while most federal transportation guidance calls for evaluating transportation infrastructure investments based on their contributions to national economic efficiency, there is no similar uniformity in the application of benefit-cost analysis. The Corps processes for the benefit and use of benefit-cost ratios is described at length here and elsewhere. Other federal jurisdictions sometimes require similar efforts and sometimes they do not. Moreover, even in those cases where benefit-cost analyses are part of the greater analytical process, they are neither conducted nor used in any sort of consistent way.

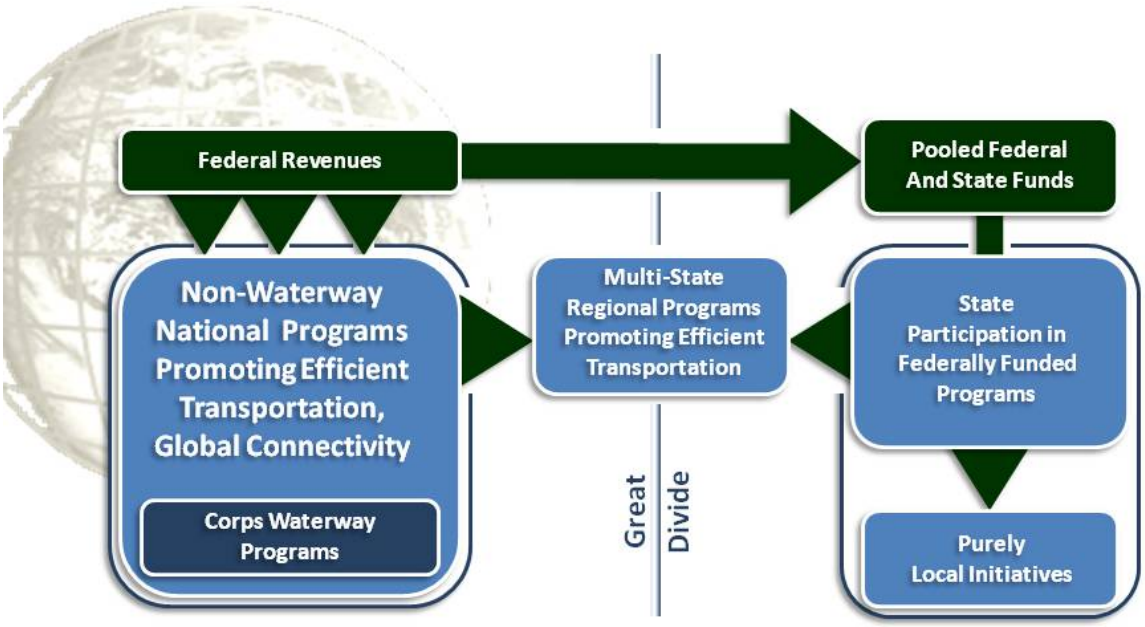

Figure 2: Transportation Responsibility and Funding

Figure 2 includes a demarcation between federal and state projects labeled *Great Divide*. There are, in fact, fundamental differences that distinguish state decision-making from the processes supposedly adhered to by federal jurisdictions. First, individual states have very little jurisdiction or responsibility for modal infrastructure other than roadways. Navigation infrastructure is the bailiwick of the Corps. The FAA exercises similar control over aviation assets. State or local planning for rail projects is dominated by the planning and decision criteria imposed by the Federal Transit Administration (FTA) and the Federal Railroad Administration (FRA). As such, local and state jurisdictions can influence infrastructure decisions for the corresponding modes (no roadway) through political activities and by providing roadway connectivity, but this influence is, in most cases, peripheral. Second, although a significant amount of the funding for such projects comes via federal sources, the federal share of state and local transportation investment for all modes has been in decline, resulting in state and local authorities becoming more engaged in finding funding alternatives. For those projects that have state or local funding options, the role of the federal government, through either alternative financing or cost sharing, and increased program flexibly, has helped to offset the lack of growth in federal funding. (The same flexibility to secure funding cannot be undertaken by the Corps, as Congress wholly determines its budget.)

The recent TIGER Grant application process provides an interesting example of the federal use of benefit-cost analysis in a transportation setting. All applications for funding under this program (Transportation Investment Generating Economic Recovery) are required to include estimated benefits within five general areas–good repair, competitiveness, livability, sustainability, and safety. Depending on the requested funding amount, applications are further required to develop corresponding benefit-cost ratios. USDOT-provided guidance indicates that

any project with a benefit-cost ratio of less than one will not be considered. Beyond this, however, there is no real indication of how benefits and costs entered the decision-making process except that the guidance states, "…the Department can consider some factors that do not readily lend themselves to monetization, including equity, and distributional, geographic and other considerations." As importantly, at least in early funding rounds, neither the grant application materials in particular, nor the USDOT in general, offer specific guidance on how the benefit-cost analyses were to be prepared.

STATE-SPONSORED TRANSPORTATION PROJECTS

With regard to roadway investments, state, regional, and local planners and decision-makers can be far more influential. However, their perspective is often quite different than that of federal decision-makers. State-level decisions are almost always more geographically constrained in the evaluation of probable impacts that underlies most investment decisions. This is neither surprising nor inappropriate; state jurisdictions preclude the imposition of policies outside the jurisdiction's borders. Moreover, state-level planners and decision-makers are not rewarded based on transportation outcomes in other states. As a consequence, state-level investment decisions routinely neglect any associated network or system impacts that occur beyond their borders. With that caveat, however, their motivations are not unlike those of their national colleagues. Indeed, AASHTO guidance on this topic suggests

> …most of the economic benefits of transportation projects come from the reduction in user costs. When trips in a particular corridor are perceived as costly, perhaps due to long travel times or high accidents rates, travelers sacrifice taking some trips in that corridor, and the economic activity associated with those trips is lost. Reducing user costs makes the perceived cost of travel cheaper, and facilitates trip making and accompanying economic activities. By balancing these accompanying user benefits against projects, we can determine which projects will provide the optimal level of net benefits to society.

The AASHTO manual provides the tools to allow the practitioner to focus on maximizing user benefits from highway projects. Travel costs define user benefits in three areas: travel time costs, operating costs, and accident costs, which as a whole represent the total price users must pay to travel. (The AASHTO manual does not discuss air pollution costs.) In a feasibility study, any reduction in costs or price becomes a benefit to the traveler. Those who were paying a certain price to travel would receive a benefit if they could travel for a lower cost. Both of the metrics discussed in the AASHTO manual, reduced road travel times and safety, are measures of efficiency gains. Reduced road travel times is a measure of willingness to pay for travel time saved and is commonly used in flood damage reduction studies undertaken by the Corps.

The final distinction between federal-level roadway planning and corresponding state-level activity comes in the area of economic development. Localized improvements in roadway performance have two distinct but largely indistinguishable impacts. They improve the efficiency of the overall system as a whole and simultaneously redirect existing economic activity from one location to another. The new economic activity that comes from the efficiency improvement is a net system gain that should be counted in evaluating project benefits. However, the redirection of existing economic activity from one area to another is an economic transfer, not a measure of any efficiency gain. The Corps refers to these transfers as Regional Economic Development (RED) benefits and does not include them in the calculation of project benefits. Other federal agencies also make this distinction in benefit attribution, albeit often with less care. State and local planners, however, can be highly motivated by the prospects of economic transfers so long as the region losing the economic activity is not within their jurisdiction. Thus, economic

transfers can motivate state-level highway policies in ways that should never occur at the system (federal) level.

EXTERNALITIES IN NON-CORPS PROJECT EVALUATIONS

The text above points to a recurring question as to whether traditional benefit-cost approaches typically applied for port or waterway project evaluations fully account for all economic outcomes that may result from a project. At issue is whether procedures or techniques should be amended to address current conditions and characteristics of the economics surrounding maritime trade and port development or whether applied techniques as originally formulated for measurement of benefits are still applicable. Key to the latter consideration is whether methods have acceptably evolved or are applicable to both current and foreseeable conditions that should logically be incorporated into related capital investment analysis. Issues of measurement also have plagued attempts to incorporate external benefits and costs into waterway analyses.

From a theoretical vantage, two points are unassailable. First, the benefits or costs associated with positive or negative externalities are just as real and just as valid as the benefits and costs that accrue directly to transportation suppliers and transport system users. The second point, which follows from the first, is that the transportation investments that result from evaluations that inadequately account for externalities – to the same degree, in the same way, regardless of jurisdiction or mode – almost certainly produce suboptimal societal outcomes.

In practice, however, the different jurisdictions that govern different aspects of modal investments in varying parts of the country treat the matter of externalities in wide-ranging and largely dissimilar ways. Consequently, harmonizing or reconciling the treatment of externalities in transportation infrastructure decision-making processes could measurably improve economic efficiency and the wellbeing of most Americans.

To better understand this issue, consider the ways that decision-makers can treat external benefits and costs. The first opportunity to account for externalities comes through the evaluation of infrastructure investment alternatives – which roads, rail lines, waterway channels, and terminals will we build? The second opportunity for useful intervention is tied to use of the networks once they are in place – how will we affect safety, fuel use and emissions, congestion, and the myriad other impacts that produce externalities, both good and bad?

In the second of these areas, we find an example of what might be done in the first. The federal government develops and enforces vehicle performance, infrastructure, and operating standards that impact safety and environmental outcomes in ways that markets would not. Standards are applied to motor vehicles, railroad equipment, freight vessels, roadways, rail lines, navigation facilities, and other infrastructures uniformly throughout the US, with variances that, at most, reflect differing geographies or modal operating properties. The same is not true when it comes to choosing the location and scale of the underlying networks.

Other parts of the current text detail how, when, and where external impacts are incorporated into navigation infrastructure investment decisions. Without duplicating this information, suffice it to say that what is done with regard to non-waterway modal networks is very different. In some cases, external benefits and costs are a much greater part of the decision-making process; in other cases externalities play little or no part in decision-making.

Externalities play a major role in the area of roadway planning and development, at least and to the extent that federal policy-makers are involved. Much like vehicle performance, operating, and infrastructure design standards, federal guidelines demand the consideration of externalities in the evaluation of roadway network projects that will be built as a part of the

federally funded highway system. These standards prescribe methods for measuring external benefits and costs and require that these external outcomes (so measured) be fully integrated into the benefit-cost calculations that underpin decision-making.

Some state DOTs mirror the federal process that requires the inclusion of externalities in network planning processes; others do not. In fact, in some states, state roadway network design decisions are purely executive in nature and are made without the calculation of benefit or costs of any kind. This is common in local settings.

The case of rail is quite different. Private firms directed by investors own well over 95 percent of all US rail trackage. These private investors or their agents decide the location and scale of railroad networks and they do so without any real obligation to the public good or any active mandate to consider the benefits and costs that accrue to anyone other than themselves and their shareholders.

In some instances, decisions to abandon or expand rail network links require regulatory approval and these approval processes may include observations regarding externalities, but two important points are clear. First, while regulatory bodies may have the ability to approve or deny private railroad initiatives, the public sector rarely has the means to actually generate these initiatives. That is left almost entirely to railroad carriers. Second, even to the extent that regulatory processes may allow the inclusion of externalities within the decision-making process, there is no prescribed set of methodologies for measuring externalities, so that consistency from one setting to the next is improbable.

Within the railroad environment, there are three exceptions to the dominance of private benefits and costs in the network investment decision-making process. First, the public sector often owns, or at least tightly controls, a small subset of rail lines used for transit or commuter operations. Second, many states own or substantially fund the maintenance of freight-only short-lines within their jurisdiction; and finally, over the past generation, some amount of public sector funding has been used to develop privately owned freight railroad infrastructures through the efforts of public-private partnerships.

In instances of public funding, either through ownership or partnership, externalities have sometimes played a major role in investment decisions. Particularly in the case of commuter operations, the ability to mitigate roadway congestion or emissions problems by providing a rail alternative has motivated a number of projects. However, the scale of this investment and its influence on overall railroad activity is small. The same is even truer of public funds for freight railroad improvements supported through public-private partnerships. The amount of these partnership funds equals less than one percent of the railroad industry's private annual investment in new track and equipment.

Within the world of commercial navigation, the vast majority of infrastructure investment decisions are controlled by the USACE or the handful of other federal entities described elsewhere in this document. The only real opportunities for non-federal investment come in the form of port and dock facilities or connecting landside infrastructure. These investments, their funding, and the decision-making that underpins them are perhaps the most varied of any outcomes for any mode. Port, dock, and supporting landside investments are funded via federal programs, state initiatives, local programs, and private investors. Some of these facilities are developed as components of broader regional freight plans and others emerge to serve the direct needs of a limited number of private customers. In nearly every instance, the development of port facilities requires an array of permits from multiple agencies, but as in the case of private railroad infrastructure, the permitting jurisdictions rarely have any authority to initiate

infrastructure developments. And again, any attention to external benefits and costs is largely incidental and without methodological standards.

5. DATA AND ANALYTICAL TOOLS

Methodological disparities in the evaluation of mode-specific transportation improvements have hampered the modernization of the overall system. In 2001, the General Accounting Office wrote,

> The federal government plays a prominent role in identifying the nation's infrastructure investment needs. Little, however, is known about the comparability and reasonableness of individual agencies' estimates for infrastructure needs.

These and other reports suggest the future of transportation infrastructure improvement in the United States depends on the development of a new transportation model that evaluates proposed improvements, based on a common set of standards applied uniformly to all modes. Recent steps by the USDOT point to movement in this direction. However, with each of these steps, it becomes clearer that the current generation of analytical tools and supporting data need improvement.

ANALYTICAL TOOLS

Freight transportation takes place over complex networks and this complexity is compounded when more than one transport mode must be considered. Even if shipped quantities are treated as fixed—a sometimes untenable assumption—changes in available infrastructure in one location almost always affect the least-cost routings or modal alternatives for an array of shipments spread widely across the broader networks. Therefore, evaluating proposed infrastructure improvements can require a great deal of analytical capacity. In response, modal experts have developed a variety of analytical tools for calculating shipment costs and allocating freight traffic to various network applications based on these costs.

In the case of inland navigation, the most advanced framework for studying the likely effects of infrastructure investments is a series of linked software products known collectively as the Ohio River Navigation Infrastructure Model (ORNIM). ORNIM is a yearly, spatially-detailed partial-equilibrium model developed and used by the Corps to estimate the benefits of improvements to the navigation infrastructure on the Ohio River System—e.g., extended or new locks, channel improvements, replacement of key lock and dam components, alternative maintenance policies, etc.—and to balance those benefits against the estimated engineering costs of the improvements. By doing so, ORNIM can identify improvements with the highest cost-benefit ratios and suggest the optimal set of infrastructure investments over time, with and without yearly budget constraints.

ORNIM is first executed for without-project conditions, which reflect a base-case level of maintenance and other activities. The model is then run for a potentially large number of with-project conditions, which may reflect new construction, major rehabs, and different maintenance policies. Non-structural measures, such as lockage fees and fuel taxes on barge operators, also can be simulated. The benefits of the river infrastructure are calculated in terms of consumer surplus and are estimated for all with-project and without-project conditions. The yearly discounted benefits are summed over a relevant time period and compared to the costs of those improvements using benefit-cost analysis.

ORNIM is not designed to estimate the total benefits of the river system nor the benefits of improving navigation infrastructure across all river systems. Total benefits to the nation would require a spatially detailed computable general equilibrium model. The partial-equilibrium approach used in ORNIM is appropriate to study the benefits of marginal improvements to

navigation, specifically NED benefits. A partial-equilibrium model assumes consumer income levels remain constant and the prices of all other goods and services, including substitutes and complements to navigation (e.g., rates for rail and truck), remain constant.

To demonstrate the complexity associated with multimodal equilibrium models to estimate NED benefits, the ORNIM system is composed of three modules and numerous sub-modules: the Lock Risk Module (LRM), the Waterway Supply and Demand Module (WSDM), and the Optimal Investment Module (Optimization). LRM takes engineering inputs—e.g., reliability estimates, component hazard functions, and repair protocols—to determine the probabilities of unplanned closures for each lock for each year. WSDM uses detailed information about the Ohio River network, towboat and barge operations (numerous tow types and barge configurations with different costs), lock operations, and exogenous cargo forecasts to estimate the annual equilibrium traffic that moves by barge. Optimization, which can be budget constrained, identifies the optimal set of investment options (e.g., construction, rehabs, and maintenance) at each lock for as much as a 50-year horizon. ORNIM's major economic assumptions are embedded within WSDM. The benefits of navigation improvements are driven in large part by relieving delays caused by congestion. Estimates of delay are exogenous to ORNIM and are provided by the Waterway Analysis Model (WAM) by way of families of transit curves. Each family of curves represents transit times for each lock and for a given number of closure days per year.

The benefits of inland navigation have focused historically on the differences between the rates for specified freight movements (origins and destinations) by barge and the least cost alternative, which in most cases is rail. The differences in water and rail rates multiplied by tons moved by barge give a simple estimate of navigation benefits.

Inland navigation systems, like other freight modes, have limitations on the amount of traffic they can process. Given a particular inland navigation system, defined by the river network, the number of locks at a site and within a river system, lock size, lock reliability, various nonstructural measures, and other factors, only a limited quantity of traffic (i.e., tows and tonnage) can traverse that system within a given time frame. As the level of traffic increases, tows on the river system experience increasing congestion and delays. This congestion and delay, which is constrained to commercial barge traffic, can be translated into dollar costs such as labor, fuel, inventory costs, and tow capacity that would not be required if no congestion existed. As more and more tows try to operate on the river system, the level of congestion, delay, and delay costs may become burdensome enough to cause tow operators to take some movements off the river system.

Figure 3 is a simple representation of navigation benefits as calculated in ORNIM. This figure represents only one of the thousands of movements (origins-destinations) provided exogenously to ORNIM, specifically to the WSDM Module. This figure represents three simplifying economic assumptions.

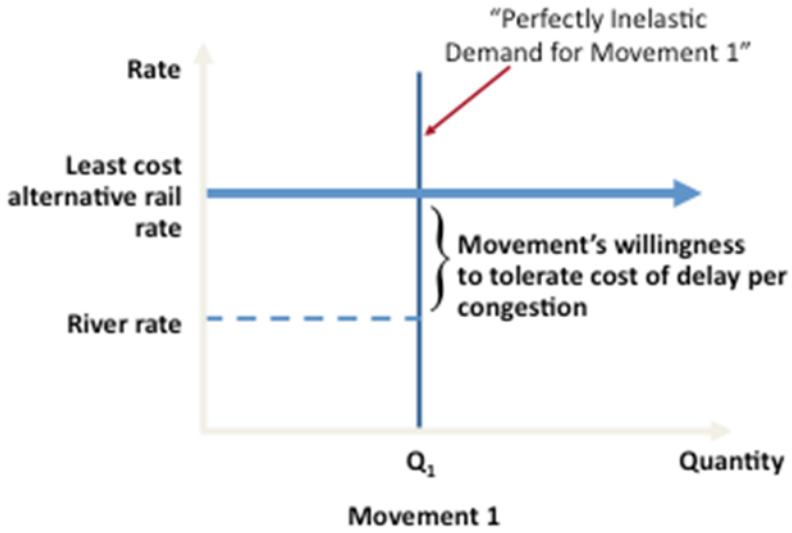

Figure 3: Navigation Benefits as Calculated by ORNIM

- The demand for individual movements is provided exogenously and is perfectly inelastic with respect to the price of river transport.
- The willingness-to-pay for individual movements on the river is equal to the least-cost alternative rail rate, which is provided exogenously.
- The supply of rail for individual movements is perfectly elastic at the given rail rate.

The benefit of this specific movement is the rectangular area bounded by the rail rate, least cost alternative rail rate, and the quantity of this specific movement Q_1. The area of this triangle is equivalent to the consumer surplus for this particular movement. Each of the thousands of exogenous movements can be represented similarly.

Figure 4 depicts elastic demand. In this case it is assumed that a portion of each movement diverts to the alternative mode as congestion costs increase. Under these assumptions, portions of individual movements stay on the river as congestion increases, and portions of the movement divert to the alternative mode. The benefits of navigation under these conditions are the total area under the individual movement's demand curve and below the river rate.

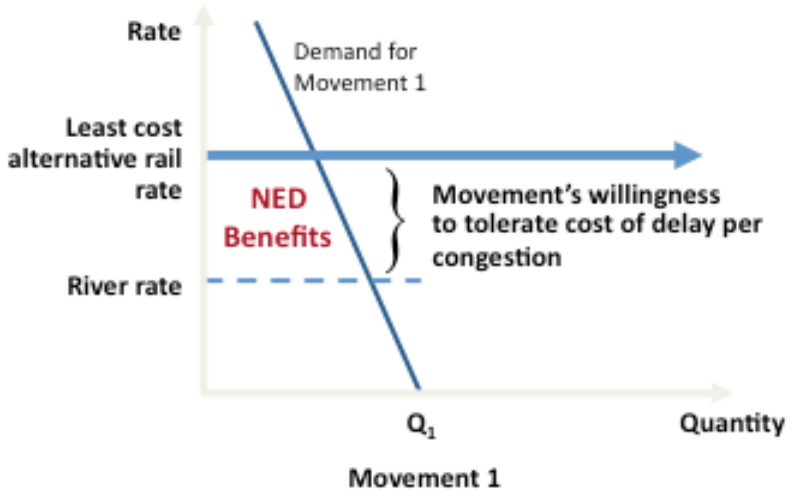

Figure 4: Less Perfectly Inelastic Demands

Stated simply, ORNIM sorts all movements according to the benefits of each movement from highest to lowest. ORNIM places movements on the river one by one, and each additional movement adds marginal congestion to the locks. At some point, the addition of one more movement increases congestion and congestion costs such that that marginal movement no longer "wants to move by water." The cost of congestion faced by that movement is greater than the rate savings—i.e., the difference between river and rail rates for that specific movement. Total benefits are the sum of benefits of all individual movements that remain on the river once congestion costs are considered.

While the ORNIM system is fairly robust, it is not directly applicable to other modal studies. Even more complex constructs are necessary to model rail and truck infrastructure improvements, where the underlying networks are measurably more intricate and more extensive and where mode switching decisions by shippers are made more sensitive by various possible rail-truck intermodal combinations. Because of these complexities, nearly every such analysis is conducted in a partial equilibrium setting where the set of potential network relationships is limited to the greatest possible degree.

TRANSPORTATION DATA

Regardless of the modes involved, the nature of proposed improvements, or the elegance of the available analytical tools, all infrastructure evaluations are rooted in a need for data. Data describing existing transportation network usage and the underlying operating and capital costs that drive this use are absolutely essential in every case. These data can be divided into three general groupings: (1) commodity characteristics such as value, bulkiness, fragility (or perishability), and degree of hazard; (2) shipment characteristics such as typical shipment volumes, equipment requirements, and geographic production and consumption patterns (both domestic and international); and (3) economic characteristics that include the costs and associated rates for providing various types and levels of service via modal alternatives, the demand characteristics of shippers in specific markets, and the degree of competition among the relevant set of transportation carriers in each market.

Data describing freight flows are available for nearly every commodity, over all modes, in the majority of markets. In the case of waterborne commerce, these flows, along with other shipment characteristics, can be gleaned through applications of data collected by the Corps'

Waterborne Commerce Statistical Center (WCSC) and through data collected at navigation locks as a part of the Corps' Lock Performance Monitoring System (LPMS). Similar data are available for rail movements through the Surface Transportation Board's annual Carload Waybill Sample (CWS). Motor carrier traffic data is more difficult to obtain, but data from the Bureau of Transportation Statistics' Commodity Flow Survey often can be supplemented with proprietary or regionally collected data to, at least, approximate truck flows.

Data describing relevant economic values are much more difficult to obtain. Only the CWS provides rate and cost information in conjunction with shipment characteristics, and the validity of these data is made suspect by reporting requirements that are designed to ensure shipper and carrier confidentiality. Still, in the cases of waterborne commerce or motor carriage, systematically collected cost and rate data are not available at all.

In the absence of available, reliable cost or rate information, analysts must take one of two paths. First, in some cases the number of potentially affected shippers is small so that surveying them to collect primary rate information is possible. This course has routinely been followed within Corps navigation studies and seems to be an ideal solution. There are, however, significant problems with using survey rate data. Even the federal entities responsible for infrastructure creation and maintenance cannot compel shippers to respond to rate surveys. In other cases, poor shipper response rates or obvious respondent biases renders survey results unusable. Also, while shippers usually are familiar with shipping rates for well-known alternatives, they often have little or no knowledge of the prices associated with more obscure freight options. Another issue is economists call *moral hazard*. Simply put, shippers often have an incentive to misrepresent the rates they face if they believe doing so will result in a favored policy decision. Finally, and most importantly from an economic standpoint, rates only approximate incremental costs under competitive market outcomes and it is the differences in *incremental costs* that are necessary to the calculation of infrastructure benefits.

The second methodological course used to fill the void in actual cost or rate data involves modeling the required shipment-specific costs. There are a variety of modal costing models available for this purpose. Some, such as the Uniform Rail Costing System (URCS) have been developed by the federal government and are made available at little or no cost to users. Other costing models are the proprietary products of private vendors. In every case, however, modeled shipment costs can introduce a lack of precision that undermines their applications in benefit-cost analyses.

Within the navigation arena, there is neither a reliable, publicly disseminated costing model, nor are there readily available proprietary models from which to choose. In response to this analytical gap, TVA developed and maintained a Barge Costing Model (BCM) that for years was used to generate incremental barge costs in Corps benefit-cost studies. The BCM, now under the direct stewardship of the Corps, provides a good example of both the advantages and limitations inherent in most similar modal costing models.

The BCM contains three costing modules: a one-way, general towing service module; a round-trip, dedicated towing service module; and a round-trip, general towing service module. The one-way module calculates rates by simulating the use of general towing conditions between origin and destination, including the potential for a loaded return. The dedicated towing service module calculates costs based on a loaded outbound movement and the return movement of empty barges to the origin dock. The round-trip general towing service module is similar to the one-way module except that it provides for the return of empty barges to the point of origin. This module does not calculate costs for towboat standby time during the terminal process but does

include barge ownership costs for both the terminal and fleeting functions. It does not require that the empty barges be returned using the same towboat.

Depending on the module in use, inputs may include towboat class, barge type, shipment tonnage, the interchange of barges between two or more carriers, switching or fleeting costs at interchange points or river junctions, barge ownership costs, fuel taxes, barge investment costs, time contingency factors, return on investment, and applicable interest rates.

Barge rates for dry commodities are typically calculated using the general towing service round-trip costing module. Inputs, based on information from carriers and the Corps' LPMS database and the WCSC data, serve as parameters within the module to simulate average towboat size (horsepower) and corresponding tow size (barges) for each segment of the Inland Waterway System. Other inputs include barge types, waterway speeds, horsepower ratios and empty return ratios.

Barge rates calculated by the using BCM reflect charges that would be assessed in a period of traditional demand for waterway service. The model does not explicitly consider market factors such as intra- or inter-modal competitive influences, favorable backhaul conditions created by the traffic patterns of specific shippers, or the supply and demand factors that affect the availability of barge equipment. These and other factors can influence rate levels negotiated by waterway users. However, the model calculates rates based on the overall industry's fully allocated fixed and variable cost factors, including a reasonable rate of return on assets. Thus, it is the Corps' judgment that the rates adequately represent the industry and provide a reasonable basis for the calculation of NED benefits.

Finally, each study is treated separately, requiring different forecasts of costs, vessel traffic, and other variables. This may potentially result underreporting the benefits of system improvements along a watershed or navigation channel.

ANALYTICAL TOOLS AND DATA GOING FORWARD

The demands on the analytical tools currently available to evaluate proposed transportation improvements are great. Fortunately, however, so is progress in the development of these tools. Geographic Information Systems (GIS) has emerged as an ideal platform for analyzing transportation data and the economic characteristics linked to spatial commerce. Moreover, the rapid development and deployment of Global Positioning Systems (GPS) continues to add increasing spatial detail to what we observe, so that our understanding of actual transportation network performance is rapidly improving. All of this is made useful by computational capacities that allow mammoth volumes of data to be sorted and streamed nearly instantaneously toward myriad uses. The ability to bring advanced empirics to infrastructure evaluation processes, for now, seems almost unlimited if the necessary data are available.

However, the advances in analytical capacity are largely offset by a decline in the availability of timely, reliable, and reasonably comprehensive economic data for public agencies. As noted above, rail carriers are the only freight providers required to report shipper charges and the quality of this information is dubious. Even the basic data describing commodity and non-price shipment characteristics is less available than in the past. Historically, transportation data collection, verification, and distribution activities have been costly to those entities responsible for this work and these same activities are (and always will be) unpopular among freight carriers who are concerned about regulatory oversight. The combined result is an observable decline in the quality of available freight data precisely at the time when analysts are most in need of it and when they are, very probably, best able to use it.

This data deficiency is unfortunate. Next-generation data collection and processing techniques suggest the high costs once associated with acquiring and preparing transportation data are (or should be) a historical footnote. These same techniques also mean that data collection need not pose a discernible burden on carriers or their customers.

6. IMPLICATIONS FOR PRACTITIONERS AND STUDY CONCLUSIONS

SUMMARY OF FINDINGS

Delivering a case that favors the careful application of sound economic principles to transportation investment decisions is beyond the scope of the current work. Moreover, it is unnecessary. Others have made this case repeatedly with a vigor and elegance that easily surpasses what might be written here. Economic benefits and corresponding costs need not be the only criteria by which competing transportation investments are judged, but these benefits and costs must be rigorously calculated and honestly represented as a part of the dialogue that informs decision-makers.

The growth in the use of benefit-cost analysis as a formal component within federal decision processes would seem to validate this conclusion. However, the segregated governance of individual transportation modes has resulted in extreme mode-specific differences in the ways that economic principles are applied. The result is a set of modally isolated transportation policies and investment priorities that preclude side-by-side comparisons that span multiple modes. Further, any *ex post* attempt to reconcile results derived through markedly different methodologies typically results in an analytical chaos that suffocates any hoped-for legitimate economic dialogue.

Against this backdrop, the current analysis has carefully attempted to review the decision processes used to evaluate proposed inland and coastal navigation infrastructure improvements. The intent was not to represent these processes as unequivocally superior to the economic methodologies applied to other modes. Instead, the purpose was to chronicle the institutional progression that led to current navigation standards, to document the complexities involved in developing and implementing sound evaluation criteria, and to highlight the differences in the standards applied to other modal infrastructure projects.

The history of navigation investment standards reveals a century-long ebb and surge of an emphasis on benefit-cost analysis that ultimately resulted in the formalization of this analytical framework within the principles and guidelines that govern navigation project approval. The latter parts of this history also document the penalties suffered when a valid methodology is purposely circumvented to attain predetermined outcomes. The pain of those penalties and the depth of the federal effort to restore credibility to these processes, together, led to a level of methodological scrutiny that has never been applied to any other transport mode and a raft of analytical and process reforms that are unmatched by the administration of any other non-waterway mode.

On the whole, the work presented here supports three general conclusions. First, the long-lived evolution of the congressionally mandated methods for evaluating navigation improvements, including strict guidelines detailing the determination of project benefits and costs, is at least as rigorous as the criteria applied to other modes and probably more so. Second, the relatively recent controversies stemming from the Corps misapplication of these methods generated both scrutiny and reforms that have no comparison among other modes. Third, as with every form of transportation, the duration of required studies, when combined with long asset lives, confounds planning processes and disillusions those directly dependent on infrastructure availability.

PRACTICAL IMPLICATIONS

Readers need not agree with the conclusions in order to concur with the resulting implications. Instead, the desirability of the overarching reforms described here rests on one simple premise: *Effective, forward-looking transportation policy depends on the improved development of benefit and cost estimates that are comparable across all candidate projects, regardless of mode*.

While the justifications for the policy prescriptions that follow from this premise seem obvious, required actions are made more urgent by three factors. First, there is a general consensus that the United States faces a looming mobility crisis that will not be ignored. This implies a need for accelerated investments in transportation infrastructure. Second, fiscal constraints suggest that every proposed transportation project is likely to face heightened competition from both transportation and non-transportation investment alternatives. Finally, efficiency increasingly dictates the combination of transport modes within multimodal corridors or as a part of intermodal service. This blending of transport modes within individual projects makes the use of mode-specific evaluation methodologies nearly impossible.

Just as justifying the use of benefit-cost analysis is outside the bounds of the current study effort, so is proffering a comprehensive agenda for the development of a single set of standards that can be applied across all proposed transportation infrastructure improvements. Still, there are certain goals that probably could achieve general support. We conclude with a brief discussion of a few such objectives.

Benefit Definitions: Efficiency Gains and Externalities. Economic theory leaves little question about what is or is not an incremental benefit that can be legitimately attributed to proposed transportation infrastructures. Net additions consumer or producer surplus are benefits, any other economic outcomes are not. Thus, if an infrastructure improvement generates efficiency gains that lower costs, these gains are benefits. It does not matter whether savings accrue to carriers, existing users, or new users attracted by the reduced costs. Benefits also include the external impacts attributable to transportation infrastructure. If a proposed project will positively impact the utility of individuals outside the transactions that rely on the infrastructure, these utility gains represent benefits that must be counted. It does not matter that these external benefits are non-traditional or that they are sometimes difficult to measure.

Benefit Definitions: National versus Regional Benefits. Most federal transportation expenditures are designed to promote mobility across multi-state regions. The net efficiency or utility gains attributable to these expenditures are the source of project benefits. It does not matter where these benefits accrue. Projects that simply transfer economic activity from one region to another or that shift surpluses between users and carriers, without any enhancement to efficiency or the net creation of additional surplus are not beneficial.

Benefit Definitions: Full Supply-Chain Costs. The Corps, as well as the administrations governing other modes, typically measures infrastructure-related efficiency gains based on reductions in total transportation costs, including line-haul costs for all modes involved, transloading costs, and handling costs at shipment origin and destination. However, these transportation charges capture only a portion of the total supply-chain costs that actually influence shipper decisions. Inventory management costs, reliability buffer costs, and a variety of modally specific transactions costs (for example, freight loss and damage claim processing costs) are not included in the assessment of infrastructure benefits. In the case of many bulk commodities, this exclusion does not lead to appreciable error. However, if a single set of

standards is to be applied to a full range of commodity movements, relying on more comprehensive supply-chain costs will become important.

Constrained versus Unconstrained Traffic. Transportation infrastructures are routinely developed to address actual or forecasted congestion delays. It is also routine for usage forecasts to allow traffic and related congestion to grow without boundaries. This unreasonably increases the benefits predicted to accrue through congestion relief. At some point, passengers or freight users will be sufficiently discouraged by congestion delays so that they abandon their planned use of the network altogether. At that point, the disutility that they incur because of congestion reaches its maximum. No more damage can be done to users who cease to use the subject network. Continuing to include incremental increases in delays for users who have dropped off the network is inappropriate. Therefore, traffic forecasts used in benefit calculations should be congestion-constrained, not unconstrained in nature. The issues of traffic demand constraints are well recognized by most practitioners. However, these issues can typically be addressed only to the extent that supporting data and computational techniques allow.

Discounting and Other Financial Parameters. It is unlikely that economic and financial experts will ever agree on a single set of discounting parameters or other financial standards. While this is unfortunate, uniformity is probably more important than a consensus on specific parameter treatment. This may mean using only real or only nominal monetary values and it may mean that discount rates are based on some blending of market returns versus the real value that consumers place on the use of their money. Others can provide better guidance on these issues. However, it is important that all benefit-cost calculations for all proposed transportation projects use the *same* set of financial practices in their calculations when at all possible.

This already difficult requirement of uniformity is made even more troublesome when project benefits accrue to a mix of public sector and private sector users. Private sector transportation users value improvements differently, count these benefits differently, and generally discount future values based on practices that are different from those used by the public sector. Moreover, private sector users are often reluctant to openly discuss their expectations regarding future benefits that accrue in the form of firm profits. In the end, these methodological issues can often lead to the use of one set of calculations in a project's benefit-cost analysis and an entirely different set of calculations for firm managers and shareholders.

Supporting Data. Section 5 voices clear disappointment at the current state of the transportation data collected and made available for analytical use in project evaluation. Currently available data do not support the existing patchwork of benefit calculation processes and they are certainly inadequate for use in a more rigorous, broadly applied methodology. This deficit is unnecessary. Moreover, until it is remedied the sum of all possible methodological reforms to the infrastructure evaluation process will yield very few improvements in analytical results.

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APPENDICES

INTERVIEWS REGARDING CORPS BENEFIT-COST ANALYSIS (BCA)

Throughout the study period, various people were approached about the use of the Corps BCA frameworks. The answers to these questions, posed to over 30 individuals involved in transportation and in countless private interviews with port directors and planners, government employees and waterway professionals, indicated how little most people really understood the actual mechanisms of the Corps BCA analysis. Most respondents requested confidentially, so the answers will provide general summaries instead identifying specific individuals or organizations. Some of the answers are listed here to provide additional comments or suggestions on the Corps BCA programs, but most echoed themes reported elsewhere.

The questions, addressed in an open-ended discussion, centered on the following:

1. **What do you think are the strengths/weaknesses of the Corps current analytical approaches using BCA?**
   - Corps Employee: Strength - framework for comparing economic performance of competing investment opportunities. Make selection of alternative investments less subjective. Weakness - analyses are often not comparable because they are not kept current or because common data sets are not used.
   - Corps Employee: Weakness - We've always limited our analysis to the waterway to the exclusion of real overland impacts that could lead to a mis-formulation (sub-optimal answer).
   - Industry Representative: The methodology appears sound. Problems stem from getting leading edge accurate freight data, and projections are so dependent on variables subject to wide fluctuations that are unpredictable.
   - Industry Representative: Ignoring RED Benefits at exclusion of NED Benefits is inconsistently applied for Corps project consideration.
   - Consultant: Strength: forced discipline on NED benefits with alternatives helps reduce wasteful spending and could be free of political posturing. Weakness: its one project at a time framework creates endless challenges from opponents to stop or delay projects and that BCA results is not comparable across projects and does not assist in prioritizing national investment strategies.
   - Corps Employee: Outages and economic analysis that are limited to travel savings for shipping companies does not capture the full effects of any significant costs when the system fails, which results in undervaluing the system's true contribution. Estimated costs of outages at our facilities are really limited to just first order effects.
   - Government Employee: The Corps tries to be more precise by forcing the BCA ratio into a two decimal place variable, which is hard to justify precisely with data and forecast uncertainties.
   - Port Executive: The Corp is reactive to the system's needs, and not being more aggressive in planning for future traffic flows (Panama Canal) to construct facilities to accommodate deeper and larger vessels.

2. What are the easiest and hardest elements to compile when doing the BCA ANALYSIS?
   - Industry Representative: Data issues are not necessarily understood, especially traffic forecast that seem based on trend lines without more shipper and study inputs.

Also, the longer horizon of the forecasts simply adds more variation to the forecast, further complicating any analysis.

- Corps Employee: The most difficult element is forecasts of future structural performance, and shipper response to waterway cost changes.
- Consultant: While it is fairly easy to get information on vessel information (Deep draft navigation), oftentimes vessels drafts are treated as a single variable, without accounting for squat or other operational characteristics.
- Consultant: Accurately forecasting market rates in today's political and economic environment (i.e., large government deficits, growth of BRIC countries, etc.) for the long-run will be difficult.
- Industry Representative: Forecasting labor and fuel costs, large components of costs for the towing industry, are hard to estimate beyond five years.

3. What elements should be included in the Corps BCA that are not included now?
   - Corps Employee: Surface transportation costs imposed by diverted waterway traffic.
   - Industry Representative: Identify factors that are subject to fluctuate and show projected conclusions as a range, not a single result.
   - Consultant: Corps BCA methodologies should estimate multimodal supply chain alternatives in multiport analysis. For many shippers, vessels characteristics are not as important as operational efficiencies at a port.
   - Consultant: Improve the linkage between benefit-cost analysis and other environmental factors, such as emissions, that would better capture other environmental issues beyond waterway environmental analysis.
   - Industry representative: When considering NED benefits, it is assumed that a plant will be built in a neighboring state, while in reality, plant and site selection now is much broad, as firms consider developing plants that serve global supply chains and not necessarily, national markets, as is assumed by the NED.

4. How does (or should) the Corps consider alternative project conditions through the use of BCA analysis
   - Corps Employee: As the BCA is only as good as the data used, the Corps tends to provide robust information on structural elements, but reaching beyond waterways in a piecemeal manner will not necessarily generate the information needed to consider alternative modes.
   - Consultant: For deep draft navigation, evaluating projects at one foot increments remains useful to better capture different construction alternatives.
   - Corps Employee: The actual consideration of project costs are done a very limited basis, so it makes it hard to develop system or network models or to link system effects across a wide geographic area. Assuming that all modal options are available, and with

unlimited capacity, seems fairly simplistic, but without a clear alternative, this approach remains standard practice.

5. What elements of the Corps BCA frameworks should be revised because of changing policy guidance or suggestions?
   - Corps Employee: Rather than chasing a changing discount rate, we ought to do the analysis at 3% and 10% which provides are range for decision makers.
   - Consultant: The incorporation of existing environmental externalities into the Corps BCA methodology should be implemented to better reflect true benefits and costs.

6. Does the Current BCA approach meet the needs of the user community (industry) in justifying projects?
   - Corps Employee: Assuming the past is prologue to the future reflects a situation 80 years ago, but it does not account for current economic conditions, especially as budgeting issues are not necessarily related to economic decisions without a clear federal vision.
   - Industry Representative: Unfortunately, in spite of the BCA favorable calculation, the Corps budget continues to not support an adequate level of spending.
   - Industry Representative: The current BCA approach may meet current user needs, but it also prevents some bad investments from being authorized.
   - Industry Representative: The growing length of study time and planning, that the needed projects are disruption user activities, resulting in foregone benefits. These long time frames may result in business' locating elsewhere that does not necessarily have the same project timelines.

7. Is the Corps BCA methodology appropriate for other agencies to use? Why or Why not?
   - Corps Employee: Yes, if there are clear societal goals to look at funding systems and not modal silos, which includes alternative formations for the Corps but also for other modes.
   - Consultant: The Corps BCA is very useful for other agencies, but cannot be used "as-is", as the NED benefits may not be forced on non-federal government agencies. As the Corps does not own other transportation infrastructure, NED Benefits may not be as easy to manage on systems with viable alternative routings. Assuming that the private sector will not respond to any changing Corps projects only serves to underscore the variability of estimating NED benefits beyond user savings.
   - Port Authority: RED benefits were just as valid as NED benefits, with the exception being a focus on policy and not economic justification.

8. What lessons, based on the Corps BCA approaches, should be applied or avoided by agencies looking to include more BCA studies in evaluating projects?
    - Corps Employee: Develop common data sets, plan in the context of a multimodal and intermodal transportation system that crosses all modes and geographies.
    - Corps Employee: The analysis is always only as good as the (input) data.
    - Industry Representative: Involve all interested parties on the front end to understand the data and projections before disclosing the results of the model.
    - Consultant: Using the Corps BCA approach may also add additional time to a project, as well as lead to the project's delay because of concerns over the selection of a NED ration into consistent with other project approval / permitting process outcomes. There is always the risk that a project will depend upon shifting traffic from another mode or port, which complicates the NED analysis.

9. How should the Corps work to better integrate its own BCA analysis with other agencies when considering national level corridor planning.
    - Corps Employee: USDOT should consider freight planning that includes all modes, which may lead to the development of a broad BCA toolkit for evaluating projects.
    - Industry Representative: The problem lies in that the Corps projects and waterways have not been given due consideration by other agencies when considering national level corridor planning. A more universal application of BCA should help to integrate such a plan.
    - Consultant: If state departments of transportation and metropolitan planning organizations are to be required or strongly encouraged to apply benefit-cost methods to all freight investments, then the experience of the Corps should be carefully considered so that mistakes are not repeated and successes are built upon.
    - Consultant: The Corps should work with USDOT modal administrations, state DOTs and MPOs to extend BCA to sets of multimodal transportation system project plans so that capital program budgets in the public sector are not developed in silos, ignoring the interactions between all elements of the transportation system
    - Industry Representative: This question gets at the core issue of a lack of a national transportation policy, which the Corps does not necessarily have the authority or the resources to develop.

10. Do you have any other thoughts or comments on the Corps Planning Process and its use of BCA to justify program expenditures?
    - Industry Representative: BCA has saved the nation from some wasteful projects. In other cases, it paralyzed decision making where BCA analysis supported the project, but some element of opposition, not focused on the financial merits of the project, hijacked the process by challenging some fact or projection and even the model itself.

- Industry Representative: Regarding the Corps Planning process, the Olmsted Lock and Dam project cost projections and completion time table suggests something certainly didn't work. In spite of the significant cost growth (from $775 million in 1988 to $2.9 billion – current estimate) and pushed out completion date from 2009 to 2022, the BCA is still favorable.
- Consultant: Without a national port or navigation plan, such analysis is hard to justify expanding beyond its current guidance, but would be a useful tool to have in a national policy.
- Consultant: As the Corps is both a regulator (permitting), an implementing agency (contracting for construction) and the planning evaluation agency for the same projects, this can lead to an inherent conflict-of-interest. This may also create an incentive to extend analysis beyond a certain point, as any delays by the Corps does not necessarily hurt the Corps, but shippers and carriers in the system.

ANNOTATED READING LIST

American Association of State Highway and Transportation Officials, User Benefit Analysis for Highways Manual, August, 2003.

This AASHTO manual provides guidance on the evaluation and development of highway projects, including the use of benefit-cost analysis and the specific benefit categories to be included within the necessary calculations.

Burgess, David F. and Richard O. Zerbie, "Appropriate Discounting for Benefit-cost Analysis," Journal of Benefit-cost Analysis, 2:2, 2011, Berkley Electronic Press, pp. 1-18.

This paper provides a theoretical basis for reconciling the use of different discount rates within the development of benefit-cost analyses.

Graham, John D., "Valuing the Future: OMB's Refined Position," The University of Chicago Law Review, 74:51, 2007, pp. 51-57.

This journal article provides a careful review and discussion of OMB Circular A-94, the federal guidance that governs the evaluation and development of non-water resource public-sector infrastructure investments.

Gramlich, Edward M., *Benefit-cost Analysis of Government Programs,* Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1997.

Volume provides a thorough summary of the application of benefit-cost analysis, particularly within the public-sector decision-making process.

Hammond, Richard J., "Convention and Limitation in Benefit-cost Analysis," Natural Resources Journal (6), 195-222, 1966.

This paper provides useful background on the application of benefit-cost analysis within the development of waterway projects and, in particular, provides information describing the use of BCA in the application of the Rivers and Harbors Act of 1902.

Hanley, Nick and Clive L. Spash, Cost-Benefit Analysis and the Environment, Edward Elgar Publishing Limited, 1993.

This text provides a useful summary of benefit-cost analysis and, in particular, traces the origins of its use to a nineteenth century Engineer named Jules Dupuit.

Lambert, Richard, "Monetary Cost of a Modal Shift," Transportation Research Record, 1998.

This study provides cost estimates related to the 1991 Neustrand study, "Environmental Impact of a Modal Shift."

Mishan, E.J., *Cost-Benefit Analysis*, 4th ed. London: Unwin Hyman, 1988.

This volume offers a thorough academic treatment of benefit-cost analysis.

Newstrand, William, "Environmental Impact of a Modal Shift," Transportation Research Record, 1991.

This work is commonly considered the first attempt to empirically measure the positive "externalities" associated with the use of commercial inland navigation. Effects are quantified; however, monetary values are not assigned.

Porter, Theodore, Trust in Numbers: The Pursuit of Objectivity in Science and Public Life, Princeton University Press, 1995.

Volume provides a thorough description of benefit-cost analysis, including its application to Corps of Engineers' projects.

Powers, Kyna, Benefit-cost Analysis and the Discount Rate for the Corps of Engineers' Water Resources Projects: Theory and Practice, Congressional Research Service, The Library of Congress June 23, 2003.

This document provides information detailing the development and implementation of the Green Book as guidance for water project investments.

Shen, H. W. editor, "Chapter 20: Federal Guidelines for Water Resource Project Evaluation." Environmental Impact on Rivers. (Fort Collins, Co: Colorado State University, 1973).

This volume chapter focuses on the development of infrastructure for multiple purposes including, navigation, flood control, water, supply hydroelectric generation, etc.

United States, Bureau of the Budget, Circular A-47 (December 31, 1952).

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United States, 71st Congress, 2nd Session, Secretary of War, House Document 328, (1930). U.S. Army Corps of Engineers, *Tennessee River and Tributaries North Carolina, Tennessee Alabama, and Kentucky*, Report from the Chief of Engineers on the Tennessee River and Tributaries, North Carolina, Tennessee, Alabama, and Kentucky, Covering Navigation, Flood Control, Power Development and Irrigation.

This document was used to justify infrastructure investments on the Tennessee River system and provides a particularly good glimpse of early Corps evaluation techniques and criteria.

United States, 75th Congress, 1st Session, "A History of Navigation on the Tennessee River System," House Doc. 254, (1937), 6.

A history of navigation on the Tennessee Rivers and its tributaries provided at a time when the federal government was in the process of developing significant infrastructures that,

among other purposes, were intended to stabilize and promote navigation. This document speaks to the magnitude benefits expected in association with these investments.

United States, 87th Congress, Second Session, Policies, Standards and Procedures in the Formulation, Evaluation and Review of Plans for Use and Development of Water and Related Land Resources, Senate Document 97, Washington, DC, 1962. Reissued in 1968; see 33 Federal Register 19170 (December 24, 1968).

The "Policies and Standards" governed the development of water projects within the US for roughly two decades prior to the adoption of the Principles and Guidelines.

United States, Congressional Research Service, Principles and Guidelines for Evaluating Federal Water Projects: U.S. Army Corps of Engineers Planning and the Use of Benefit-cost Analysis, August 2009.

A course capstone project from the Evans School of Public Affairs University of Washington, this provides a current evaluation of the Principles and Guidelines and its applications in the wake of earlier controversies and more recent analytical technique development.

United States, Government Accountability Office, A Comparison of the Costs of Road, Rail, and Waterways Freight Shipments That Are Not Passed on to Consumers, GAO-11-134, January 20011.

This GAO report outlines the theoretical basis for including external benefits and costs within the evaluation of proposed transportation infrastructures, then advocates their inclusion.

United States, Natural Resources Board, A Report on National Planning and Public Works in Relation to Natural Resources and Including Land Use and Water Resources With Finding and Recommendations, 267 (1934).

Among other outcomes, this document codifies the requirement that benefits exceed costs for all Corps of Engineers projects.

United States, 16 U.S.C Section 460, Water Resources Development Act, March 3, 1974, P.L. 93-251, amended the Federal Water Project Reclamation Act.

This act was the first "WRDA", the Congressional vehicle of choice for establishing water project policy and the means through which most project funding is provided.

United States, 42 U.S.C. 1952, The Water Resources Planning Act of 1965 (P.L. 89-90, 78 Stat. 245.

Enacted in the era before the Principles and Guidelines replaced the P&S, this statute embraces multi-purposed projects and makes clear that efficiency gains are not to be the singular (or even dominant) determining factor in investment decisions.

United States 42 U.S.C. section 1962-a-2, "Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies."

The PRINCIPLES AND GUIDELINES, the current guidance governing the evaluation, development, and implementation of water resource projects in the United States.

University of Tennessee, Center for Transportation Research, Social Costs of Barge Cargo Modal Diversions Due to Unscheduled Closures of Emsworth, Daschields, and Montgomery Locks, prepared for the Tennessee Valley Authority, 2008.

This report details the empirical methods and result used in a number of TVA studies aimed at quantifying the external benefits attributable to commercial inland navigation, so that these benefits might be included within the NED analysis outlined by the PRINCIPLES AND GUIDELINES.

Wellington, AM, *The Economic Theory of the Location of Railways*, John Wiley & Sons, New York, 1887.

Primarily focused on civil engineering, this volume also provides an example of economic thinking as it was applied to for-profit project development during the nineteenth century.

Zerbe, Richard O. Jr, *An Ethical Benefit-cost Analysis*, The Evans School of Public Affairs and the Law School, University of Washington, paper for the 2006 Cost-Benefit Conference at the Northwestern University School of Law.

Conference presentation provides an explanation and applications of the Kaldor-Hicks efficiency criteria in benefit-cost analysis. This criteria is similar to classic Pareto efficiency except that the necessary criteria for an efficient outcome are less restrictive.

Applying Benefit-Cost Analysis to Freight Project Selection: Lessons From the Corps of. Engineers. Final Report.Â i. Applying benefit-cost analysis to freight project selection: lessons from the corps of engineers. Final report contents. List of tables and figures .iii Author acknowledgements.iv.