APPLYING BENEFIT-COST ANALYSIS FOR AIRPORT IMPROVEMENTS: CHALLENGES IN A MULTI-MODAL WORLD

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Note to reviewers: This document discusses differences in guidance documents offered by various federal agencies, but it neither criticizes any agencies nor recommends that any agencies adopt particular policies. The work on which it was based has passed TRB's Cooperative Research Program panel review for independence from policy recommendations.

ABSTRACT

Benefit-Cost Analysis is widely used for airport investment analysis, including both ranking of alternatives and funding decisions. While the technique is theoretically straightforward, its application can become complicated by a series of factors that are particularly problematic for aviation applications. This includes the fact that aviation travel also requires ground access travel, making it intrinsically multi-modal. In addition, the speed of air travel attracts classes of users and dependent parties with particular speed sensitivities and delay consequences. So when benefit-cost analysis is applied for airport project proposals, it can raise issues of how to handle competing modes, inter-modal interactions and definitions of who are the real users and beneficiaries of airport improvements. To examine these issues, the authors compared benefit-cost guidance for airports with counterpart guidance for other travel modes, and also conducted a review of the current state-of-practice of benefit-cost studies for airport improvements. The findings point to challenges for improving future analysis methods of airport benefit-cost analysis.

BACKGROUND: BENEFIT-COST ANALYSIS IN AVIATION PLANNING

*Need for Benefit-Cost Analysis***.** Benefit-Cost Analysis (BCA), which is sometimes also referred to as Cost-Benefit Analysis (CBA), is an analysis technique used to compare of the economic efficiency of proposed public investments. It works by measuring streams of benefits over time and streams of costs over time, and then expressing them in terms of their discounted "present value." In theory, it provides a straightforward and consistent way to compare rank and select among competing alternatives that may differ in timing and/or scale. This characteristic enables its use for answering three kinds of questions based on economic criteria:

- Do the economic benefits of a proposed project justify its economic costs?
- Among competing alternatives, which should be selected?
- Among selected projects, what should be their priorities and timing?

BCA has become an accepted standard for funding decision-making particularly for large infrastructure projects, due to the greater magnitude of stakes and risk associated with such projects. It has become widely accepted for aviation capital investments, as the resources required for building new airports and expanding existing airports can be quite significant. In the US, BCA studies have been required for federal grant applications for capacity projects for local airports (over $5 million each) under the "Airport Improvement Program" since at least 1994. Such studies are also required and commonly conducted for assessing airport projects in other countries.

BCA Challenges. As a tool for public investment decision-making, BCA focuses on the "net social benefit" or "social return on investment." In this context, the word social refers to societal benefits and costs, which include public, private, and government benefits and costs. Ideally, it is used to identify all impacts to society associated with taking an action, regardless of whether the impacts come as a cost or benefit or whether they are borne by the government or a direct beneficiary or a third party. In economic terms, BCA can identify which project maximizes net social benefit.

This immediately raises the issue of what is a "project." In the context of airport planning, a project is often a bundle or package of actions that reinforce each other. For instance, a runway extension to expand capacity may be bundled with lighting enhancements needed with it to enhance safety. Or expansion of air-side facilities may be bundled with ground-side access improvements needed to serve the anticipated activity growth. Or taxiway and apron facilities may be enhanced together with a terminal expansion. The difficulty for BCA arises when only a portion of these bundles can be considered in the funding decision. For instance, airport safety improvements are typically mandated by regulation rather than BCA-based evaluation. Road access to airports may be in the decision-making purview of a highway agency rather than the aviation agency. And in the US, federal grants to local airports can fund air-side improvements but not terminals. So in each of these situations, a government agency may wish for BCA to consider only a portion of the bundle.

Another issue is the definition of what is a “user” of “beneficiary.” In the case of general aviation airports, there are uses for medical emergency (e.g., organ transport), military and civilian flight training, and recreation (including commercial air shows) that require some form of valuation or consideration in decision-making. Some general aviation airports also serve as support centers for industry clusters, handling emergency replacement shipments for just-in-time production processes, which typically involve charter and private industry aircraft. In all of these cases, the benefit may be quite different from the traveler time and cost savings factors that are commonly used for ground transportation. And in all of these cases, it may be argued that the true user of the aviation services is the medical center, educational institution or industry that chartered or paid for use of air service, rather than the pilot and passenger. The possible need to consider wider definitions of airport users and beneficiaries can raise additional challenges for the application of BCA to airport projects.

METHODOLOGY

To examine these issues, the Airport Cooperative Research Program, which receives its funding from the (US) Federal Aviation Administration, commissioned funded a study to synthesize current benefit-cost analysis practices and findings as applied to airport capacity projects [1]. There were three parts to the research effort. First, there was a comparison of similarities and differences in BCA guidance prepared by different US national agencies covering various modes (aviation, highway, transit, rail and marine), as well as international agencies (including US, Canada and Europe). Second, there was a review of methods used in twenty-four BCA studies that were submitted to the FAA, as part of funding applications for proposed airport improvement projects. Third, there was an analysis of the adequacy of current BCA methods in capturing the types of benefits that were motivating the various project proposals. This article discusses key findings from that effort as well as additional subsequent observations added by the authors.

LITERATURE REVIEW: BCA GUIDANCE FOR DIFFERENT MODES

There is a long history of applying BCA for transportation projects spanning all modes, starting with its application for waterway infrastructure projects by the US Army Corps of Engineers (ACE), which was required by the Federal Navigation Act of 1936 and Flood Control Act of 1939. In 1992, the US Office of Management and Budget (OMB) Circular A-94 laid out federal guidelines for benefit-cost analysis of all federal programs [2] and that was followed in 1994 with an Executive Order requiring federal agencies to implement systematic analysis of transportation infrastructure project benefits and costs [3]. Since then, the Federal Aviation Administration (FAA) has also required BCA for its discretionary airport capacity project funding grants [4].

Within the US, the FAA and ACE are but two of many transportation-related agencies that call for benefit-cost studies for funding capital projects. The Federal Railroad Administration (FRA) provides guidance for required BCA of high speed rail proposals. It had also required BCA studies for its local rail freight assistance program, but that program is no longer funded. The Federal Transit Administration (FTA) requires calculation of project benefits and costs for its New Starts program, although they are combined in a modified form of cost-effectiveness analysis. In addition, the Federal Highway Administration (FHWA) encourages the use of BCA and provides tools for state agencies to conduct BCA studies.

For this study, the review concentrated on BCA guidance documents of multiple modes, spanning national-level agencies in the US and selected other transport agencies abroad. Guidance documents reviewed incorporated highway, transit, freight rail modes and multi-modal systems, as well as aviation. A listing of documents is noted in references five to sixteen in the bibliography of this paper.

It should be acknowledged that there are many other guidance documents that have been issued by state agencies within the US and national agencies in other countries that also define BCA procedures within their jurisdictions.

FINDINGS ON USER BENEFITS

The various BCA guides were first reviewed to examine similarities and differences in how narrowly they define benefits and costs. The comparison of guidance documents found that all recognize the same general elements of (1) user time and cost savings benefits, as well as (2) safety and (3) environmental externalities. However, there are notable differences among the modal agencies in their definitions of users and inclusion of economic externalities.

Definition of Users. All of the guidance documents define key benefits of project alternatives in terms of the time and money cost to operators and travelers. Current aviation guidance also recognizes shippers, who may incur additional costs (above and beyond the pass-through of operator costs) for delays that affect inventory carrying costs, spoilage and logistics processes [5]. Such impacts can be important for aviation because air freight tends to have a particularly high value and time sensitivity. Going back to 1990, the FRA guidance had also defined cost savings benefits of rail freight in terms of shipper costs [10]. In addition, a study for FHWA recommended the addition of shipper "logistics costs" savings in BCA studies for freight-related projects [17]. However, most of the other guidance documents are silent on the treatment of freight shippers, which could be interpreted as implying that shipper benefits are covered insofar as they are represented by the valuation of project impacts on operator costs.

Intermodal Efficiencies. There are also significant differences among the modal guides in their attention to multimodal interactions. For example, the FAA's aviation guidance explicitly defines "users" as the "aviation public." This definition is multi-modal to the extent that other modes (e.g., road and transit) are used to access airports. For instance, a number of airport BCA studies include benefits of improving an existing airport associated with savings ground access costs. The classic example would be the case where expansion of a new airport enables new air service, that allows some air travelers to use a closer airport and hence reduce ground travel time and cost compared to what would otherwise be incurred in accessing a more distant airport.

This definition of the "aviation public" does not, however, extend to users of other modes along the same travel corridors. So it would not count benefits accruing to car or truck travelers if, for example, an aviation project reduces highway congestion or railroad operating costs because of mode-switching behavior. Current aviation guidance allows for new aviation travel caused by an airport improvement to be recognized as an induced benefit, valued through consumer a surplus calculation, although this is a practice that is rarely applied to aviation infrastructure projects [5].

In contrast, highway and public transit BCA studies [7, 12] tend to explicitly include multiple ground transport modes such as cars, trucks, buses and rail transit, and thus the time and cost impacts of switching among those modes are often directly calculated. However, BCA studies for highways and public transit usually ignore intercity rail, marine and aviation modes because they are not covered by ground transport network models. BCA studies for high speed inter-city trains, though, do typically include competing train, car and bus modes [11].

User Safety. Safety benefits are handled quite differently in aviation BCA guidance than in any other modal guidance. This is primarily because aviation crashes are extremely rare; however, when they occur, they can be very costly. As such, predicting safety benefits is statistically difficult. Moreover, FAA explicitly incorporates safety benefits within its own infrastructure, such as safety towers. FAA's approach is to treat most safety benefits as regulatory requirements, where "no benefit can be claimed" [5, p. 48]. Some safety benefits are permitted, however, depending on the regulatory attainment of preexisting infrastructure. This approach is necessarily different from other guidance, particularly for road and rail modes – where crash and injury rates and consequences of projects can be estimated.

User Delays from Construction. Use of facilities during ongoing construction can mean some additional delays. This issue is most common for road and rail projects, and is typically addressed as a short-term dis-benefit in BCA guidance for those modes. It tends to be less of a problem for airports, and hence it is not entirely surprising that the issue is not addressed in current aviation guidance.

FINDINGS ON VALUATON OF TIME DELAY

Passenger time savings. There are notable differences among the modal agencies in their value of time. In particular, ground access time savings (for trips to the airport) is valued differently by the highway, transit and aviation agencies. In particular, US federal guidance recommends that the use of a higher value of travel time delays for air travelers– whether they are moving in on aircraft, sitting in a terminal waiting, or moving on the ground to/from airports – than would apply for road or rail travelers. (See Exhibit 1). The reasoning is that air travel delay costs apply to a certain segment of the travel market that is particularly time sensitive and willing to pay more for time savings. While this is logical, it nonetheless presents challenges for multi-modal planning, particularly when options involving different combinations of modes are considered.

The differences in value of time can also become accentuated over time because aviation guidance states that the values of times should *not* be adjusted by analysts for inflation, but should rather adhere to given constants. That was presumably done to aid in internal consistency for evaluation of competing projects that may have been studied in different years. However, highway and transit values are often adjusted to the current year. In reality, some BCA studies conducted for airport projects have also adjusted the value of time because the most recent guidance was considered to be out of date. The issue that remains is that there is not full consistency between modal agencies as to either the basis or the frequency of updating travel time valuation factors.

Exhibit 1. Value of Passenger Time Savings

Modal Agency	Business Travel	Personal Travel
Aviation (FAA), 2002	$40.10	$23.30
Highway (FHWA), 2002	$21.20 (+)	$10.60 (+)
Transit (FTA), 2006	$10.54 (+)	$10.54 (+)
Transit (TCRP), 2002, adjusted to 2007)	$19.14 (+)	$ 9.57 (+)

(+) indicates that values increase annually with inflation (e.g., the FHWA business value would rise to $25.30 for year 2007).

Freight time savings. In recognizing three types of time cost savings to freight shippers, the aviation guidance is among the most comprehensive in its treatment of freight delay reductions. These unit values of time delay may include: (1) the value of tied up inventory, expressed as its hourly interest cost, (2) "spoilage" costs, and (3) costs from logistical bottlenecks. For the latter two cost types, FAA guidance call for supporting evidence but FAA makes no methodological recommendations [5].

In contrast, most highway-related guidance documents define freight time savings only in terms of the cost of operator and vehicle time [8,9], though logistics costs are recognized as a legitimate element of truck and rail freight in BCA guidance posted by the FHWA Office of Freight [17]. Multi-modal guidance documents also recognize freight inventory value in the calculation of delay costs [14] and that factor is incorporated into some highway analysis systems (such as FHWA's BCA.NET system). The TREDIS multi-modal analysis framework further allows for inclusion of both freight value and logistics costs in a multi-modal BCA [18]. Taken together, the implication of these various modal discrepancies in valuation of freight time delay is particularly problematic for aviation planning. That is because aviation attracts the most time-sensitive freight deliveries, so differences in the treatment of this factor can have a substantial impact on comparison of the relative value of aviation vs. non-aviation projects.

FINDINGS ON NON-USER BENEFITS

All guidance documents reviewed here recognize at least some "external" or non-user impacts of transportation projects, but details of which impacts are considered and how they can be quantified differs considerably among US and international organizations. Some of the key differences are discussed here.

Air Quality Benefits. Environmental costs (and associated benefits from their reduction) are the most commonly quantified externality among agencies. However, different forms of environmental impact arise for different transportation modes, and their treatment also differs by mode.

Air quality benefits can come from nearly any kind of transportation improvement. For road and rail transport projects, air quality impacts are valued in monetary terms. The values set for such impacts, however, is a rapidly evolving field as discussed in a recent NCHRP review [19]. However, aviation guidance in the US is considerably different from that for other transport modes. As with safety and security, air quality benefits of aviation projects are treated primarily as a regulatory requirement. In particular, it is made clear that no benefit attribution is allowed for compliance with regulatory requirements that would not have been necessary if the project was not built. However, some environmental benefits of airport projects are allowed in areas not attaining Clean Air Act standards [5]. Overall, it appears that treatment of environmental impacts among various modes can be explained by internal logic that makes sense for each mode when considered separately, but which nonetheless complicates cross-modal valuation of alternatives.

Noise pollution is also a major concern for airports, so it is not surprising that it is recommended as an element of airport BCA studies [5]. The valuation of noise benefits (or dis-benefits) is also recognized in multimodal BCA guidance in Canada and Europe [14,16] and in the TCRP Guide [7]. However, most of the other modal guidance documents, including highway BCA guides, are silent on noise impacts. This is not particularly surprising, given that noise is more likely to be a factor for road and rail projects.

Economic Productivity and Macro-Economic Benefits. Economists define productivity as the amount of output produced by a firm or industry per unit of input (typically defined as labor or capital). There is general acknowledgement that transport projects can have the ability to stimulate increased business productivity and economic growth by enabling economies of scale, agglomeration or reorganization of business processes. The potential for productivity impacts is recognized in most guidance documents, though there is disagreement concerning their inclusion in BCA studies. For instance, FAA guidance recognizes the potential for further productivity benefits associated with “logistical response” but it states that “given the early stage of development of this type of analysis, FAA will consider claimed productivity gains separately from conventional BCA results” [5]. FHWA’s freight BCA study similarly recognized that a primary mechanism for productivity improvement occurs as freight shippers respond to lower transportation costs by adjusting inventories or shuffling logistical activities [17]. Industry-level productivity impacts are also recognized in Canadian BCA guidance [16]. However, no clear consensus has emerged as to how to measure such benefits in BCA at this time.

Ironically, economic productivity is often cited as one of the chief justifications for national-level transport funding. But on the other hand, there is concern about double-counting of benefits in BCA studies. In particular, it is possible that some elements of productivity benefit may be included in separate estimates of consumer surplus gained from induced travel. For instance, if the cost of freight transportation drops owing to additional transportation investment, then firms may choose to purchase more transportation to economize on other production costs such as inventories and logistics. To the extent that these decisions are reflected in induced travel on the facility being studied, their inclusion could potentially constitute double-counting of benefits.

EFFECT OF SHIFTING DISCOUNT RATES

Ultimately no factor can change the results of BCA studies, or the comparison of projects, as dramatically as the choice of the discount rate. The reason is that the capital cost of new projects occurs largely as an "upfront" expenditure associated with materials and the construction process. Conversely, project benefits occur sometime later, starting after the construction is finished and continuing into the future. Therefore, a higher discount rate has the effect of reducing the PV of benefit streams extending into the distant future, while having relatively less impact on cost streams that are incurred mostly upfront.

This effect is illustrated in Exhibit 2, which shows that a project that passes the BCA tests (i.e., has benefits greater than costs) with a low discount rate may fail if a higher discount rate is adopted. The problem is exacerbated by the fact that aviation projects can have faster time frames (often 1-4 years) than highway and rail corridor projects, especially if the latter involve development of new right-of-way (which can take a decade or longer). So use of higher discount rates in BCA studies can favor shorter-term projects such as airport development over longer-term projects such as new rail lines. Conversely, lower discount rates can switch results in just the opposite way, giving more of a boost to longer term rail projects.

Exhibit 2. Benefit-Cost Ratio Varies by Discount Rate

Example: Nominal Cost of $13.9 million spent over the first 4 years and Benefits of $28 million spread over the next 20 years.

Discount Rate	All dollars are in thousands			**Benefit/ Cost Ratio**
	Present Value of Benefit	**Present Value of Cost**	**Net Present Value**	
10%	$ 7,346	$10,925	($3,579)	0.67
7%	$10,549	$11,700	($1,151)	0.90
5%	$13,368	$12,267	$1,401	1.11
3%	$17,985	$12,881	$5,104	1.40

Unfortunately, there is no agreement among different levels of government within the US, or among nations outside of the US, as to what is the most appropriate discount rate to use. The FAA guide for federal aviation projects [5], along with counterpart rules from other US federal agencies, requires use of a 7% discount rate for all projects based on the OMB's Circular No. A-94. That document, developed back in 1992, called for a 7% real discount rate when evaluating federal regulations and investments, with the explanation that it "approximates the marginal pretax rate of return on an average investment in the private sector in recent years." The quote continues, "significant changes in this rate will be reflected in future updates of this Circular." [2]. However, no such updates were published, as OMB subsequently decided to discontinue that series. Meanwhile, OMB has continued to publish a separate series of annual updates to the recommended discount rate used in lease-purchase and cost-effectiveness analyses. The latter rate, which was 5% in 1992, is currently down to 2.7% as of December 2008 [20].

Other, more recent guidance documents, now call for discount rates substantially different from the OMB's 1992 recommended value. The Highway Economic Requirements System - State

Version (HERS-ST), for example, recommends a real discount rate between 3% and 5% (with 7% for sensitivity analysis) [8]. The FHWA's "Economic Analysis Primer" recommends that states adopt a rate tied to the cost of government borrowing, and suggests a range between 3% and 5% [9]. The European Commission also recommends 5% [14]. On the other hand, Transport Canada recommends a 10% real discount rate (using 5% and 15% in sensitivity analysis) [16].

Regardless of the specific discount rate recommended, all of the guidance documents that were reviewed do call for using a fixed discount rate when comparing projects, and most call for using a consistent rate to allow for comparison among competing projects and among alternative time frames for project development. However, the guidance offered by different agencies currently prevents such consistency in decision-making across different types of projects, locations and jurisdictions. The problem may be most severe when an airport project bundle includes some elements that are eligible for federal funding and other elements that are eligible for state funding, with different discount rates required by each agency.

OTHER CONSIDERATIONS NOT COVERED BY BCA

There are additional forms of non-user impact that are typically not covered by BCA. They include both (1) distributional impacts among areas of impact, and (2) impacts on external funding availability and (3) financing implications. Each is noted below.

Distributional benefits. Airport investments (or other forms of infrastructure investment) that are made in economically distressed communities may have the further social benefit of shifting aviation activity to create more income in areas of economic need rather than areas where economic growth is already high. Additional jobs and income may be attracted to the local area (and some local jobs at risk of being lost may be retained) because of enhanced local business competitiveness enabled by airport access and service improvements. These may be considered to be spatial redistribution benefits or they may be considered to be local economic development benefits. In some cases, the effort to further local economic development may be an explicit goal of the investment. For those cases, it may be misleading to ignore it in BCA measurements and merely relegate it to the class of distributional impacts. Instead, techniques that isolate such impacts such as local economic impact studies may be more appropriate to directly assess that class of desired impact [21].

Leveraging of Other Funds. The addition of federal capital investment funds for airport improvements can leverage additional investment in community facilities by local government, by airlines, and by local businesses. These additional investments may create or improve terminals and other on- and off-site facilities and services, benefitting both visitors and locally based travelers.

These types of impacts may increase difficulties to obtain a BCA greater than 1.0 for any of three reasons. First, the additional funding may cover costs of other projects that are distinct and necessarily separate from the project that is the subject of the current BCA. Second, if the additional funding expands the current project, then it would lead to revision of both the benefits and costs, with no guarantee that the net benefit would improve at all. Third, the additional funding may be seen as leading to localized benefits that are nonetheless transfers (among

locations or among parties) rather than benefits when viewed from the national perspective adopted by the federal government.
FAA insists that all project costs be incorporated in the cost analysis of a project. On the other hand, economic development organizations, such as the Appalachian Regional Commission (ARC), recognize the leveraging of both private investment and money from other agencies as a measurable benefit of its infrastructure investments in economically distressed region. Typically, however, leveraged funding is not included in BCA studies for federal agencies.

Financing Implications. BCA considers the long-term costs and benefits of projects, but not their investment requirements and cash flow consequences. Yet a project with high net social benefits is still unfeasible if there is no way to pay for it. For that reason, state and local agencies, as well as private owners of aviation facilities, often seek to conduct financial analyses to assess the upfront investment cost and subsequent cash flow implications of project funding. This is particularly necessary for air terminal projects that are not eligible for federal capital investment funding. From an organizational perspective, financial analysis determines whether a project is affordable at the time of construction, during a foreseeable operational period and in relation to other potential investments.

Financial analysis has several types of uses. It can be used to ensure that a project maintains a positive cash flow (to pay for project construction and projected annual operating costs) and adequate margins for debt-service coverage, if applicable. It can also be used to calculate a project's internal rate of return, relative to alternative investment options. Financial analysis is also commonly used to evaluate private sector-funded projects, proposed privatization schemes, or toll pricing studies. In addition, most airports that are operated by private entities or quasi-public authorities also conduct their own financial analysis of revenue and cash flow.

CONCLUSION: NEEDS FOR FURTHER RESEARCH

Limits of BCA. There is a general consensus among transportation agencies that BCA can be a useful tool for decision making, but cannot be the sole basis for decision making. There are two reasons for this.

- BCA is a measure of the "efficiency" but not the "equity" of investment decisions. While it establishes that the beneficiaries could theoretically compensate those hurt or otherwise not benefitting from a project, there is still a real public interest in equitably distributing both costs and benefits of public investments, and that must be taken into account outside of BCA.

- BCA can reflect the net social benefit or net social return on investment only to the extent that all cost and benefit factors are measured in dollar terms and thus incorporated into the BCA calculations. Any additional positive or negative factors that are not quantified and monetized within the BCA calculations must be recognized outside of the BCA results.

Both of these considerations lead nearly all transportation agencies, including aviation agencies, to consider BCA results as just one element in funding decisions, and to also consider both equity and hard-to-quantify social benefits in making funding decisions.

Yet even with additional factors considered outside of BCA, there remain a number of challenges to BCA that involve its susceptibility to modal bias. First and foremost, there is a clear need for further action to standardizing BCA processes, particularly as they relate to the definition of users and beneficiaries, and the setting of discount rates. In addition, there are four topics where further research is needed to establish appropriate standards and processes. They are: (1) research on the valuation of air freight time delay and reliability, (2) treatment of benefits that are shared or span across multiple modes of transportation, (3) treatment of state and regional air network efficiencies that differ from single airport benefits, and (4) relationship of economic development benefits to BCA. They are discussed below.

1. *Research on Freight Value of Time Delay.* Air freight impacts have received far less attention in BCA guidance documents than air passenger impacts. However, the need for more research and guidance on air freight benefits is growing. Air freight is the fastest growing element of freight movement in North America (in terms of a percentage growth rate). As long-distance supply chains have evolved and product markets have become more national and global in scale, the economic importance of air freight in general, and the role of air freight gateways and their ground access connections, has also grown. Future ACRP studies will examine the economic impact and value of air freight activities at airports. However, there is an additional need to improve future airport BCA studies through additional research and guidance pertaining to both the scope and measurement of freight impacts. The relevant aspects of this topic include the following:

    - *Value of time delay and reliability for air freight.* A flurry of recent studies have covered the value of time delay and reliability changes for trucks, and the applicable values for air freight are also needed. In particular, research is needed to improve aviation stakeholders' understanding of appropriate valuation of delay for time-sensitive deliveries and the just-in-time processes that depend on them. In all likelihood, these values may depend critically on freight mix and they may change as technologies evolve.

    - *Treatment of aviation-reliant and airport-related business.* The definition of what constitutes the "aviation community" has changed as air freight has grown in importance. Traditionally, airport BCA studies focused on interviewing air travelers, air carriers, and airport-related businesses (primarily fixed-base operators) for information on how airport improvements would affect their costs and benefits. However, with the growth of air freight, many businesses are not airport related, yet they depend on air parcel carriers and commercial aviation (through belly freight) for incoming supplies and outgoing orders. The benefits of enhanced air services for the productivity of these aviation-reliant businesses, the ultimate users of air freight, may be significantly larger than the benefits reported by commercial and charter carriers. Further research is needed to better understand the valuation of benefits for this group and to recognize these benefits without double-counting the benefits to air carriers.

- *Reliability.* As virtually all freight enter and exit airports via some form of ground transportation, the research on costs concerning the value and reliability of freight should be shared among all modes.

2. *Research on Inter-Modal Interactions.* All airports are multi-modal ground and air interchange terminals. Similarly, both railroad intermodal facilities and marine ports are also multi-modal interchange terminals. It is thus logical that BCA studies consider benefits and costs for all affected modes as coordinated multi-modal initiatives. Yet as it stands today, however, a package of multi-modal improvements cannot be measured in a single BCA within the US. However, current practice in the US is for a coordinated project of roadway, rail and aviation improvements to be split apart and analyzed through separate mode-specific guidance documents and regulations. This approach prevents BCA from considering the synergy of a multi-modal package.

   Insofar as an airport improvement project may affect traffic on access roads and related connectors, it would make sense to measure the benefit and cost implications of those ground transport changes, regardless of how many of the affected parties are ultimately accessing the airport. By the same token, many road system changes also may affect the travel routes of some people or cargo to and from the airport. However, we recognize that a "slippery slope" toward overreaching or double-counting benefits is introduced if aviation planners count benefits for non-aviation road travel, while road planners count some of the same benefits for airport access. In particular, multimodal planning of joint improvements could lead both parties to count some of the same benefits. Further research is needed to untangle the relationships in multimodal interactions, how they can be exploited for better planning, and how they need to be carefully counted to avoid error in BCA.

3. *Treatment of Network Efficiencies.* One of the issues facing BCA studies for individual airport projects is the loss of information about interactions among airports. In some cases, improvements to one airport may lead to spillover benefits for other airports. In other cases, improvements to one airport may reduce the future benefit of previous investments in competing airports. The issue is recognized in FAA guidance, but the tools to untangle and address these issues are not well developed. Some states, when developing their State Airport System Plans, have considered these issues. Further research is needed to develop better analysis methods that could be used to enhance public investment decision making.

4. *Relationship of Economic Development and BCA.* Many times, airport improvements are sought to support local and regional economic development. Often, the motivation is to reduce economic distress in areas of high unemployment and low income, which are acknowledged federal interests. However, traditional BCA does not provide any way to recognize distributional benefits. Methods are not yet developed to place a federal or state value on the reduction in government transfer costs (such as welfare, food stamps, and unemployment payments) associated with reducing economic distress, or other hard-to-quantify benefits of local or regional economic development. Because such benefits are commonly recognized by the public, further research may be appropriate to investigate ways that such economic development benefits can be recognized in investment prioritization and decision making.

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