PRACTICE AND ISSUES IN ECONOMIC ANALYSIS

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Historically, FAA's practice has been to estimate the benefits of safety regulations only in terms of the extent to which safety is enhanced or risk is reduced. While this approach may be satisfactory where the effects of regulation are largely limited to reduction in accident costs, FAA has recently come to the view that regulatory actions have a wider impact and that benefit valuation should extend beyond safety to other areas of public benefit.

This paper reviews the range of benefit categories identified in the October 1995 scoping session and suggests certain revisions. It also examines major issues concerning benefit valuation and offers some sense of the priorities for further research. Before addressing these matters, some general points about the economic analysis of benefits need to be understood.

CONCEPTUAL OVERVIEW

The starting point is the premise that the benefits of government intervention in the marketplace somehow change the way certain things are done. The focus here is regulatory intervention, but the principles are the same for other actions such as investment or taxation. The analysis required to establish the economic benefit of government action consists of three distinct phases:

- Operational—determination of what happens, in physical or operational terms, as a result of the government action, i.e., what changes actually take place;
- Identification of benefits—precise identification of which changes are economic benefits; and
- Valuation of benefits—establishment of a money value for those benefits.

Operational Analysis

The operational phase should be completed before the economists begin their work. Estimates should be made of the effect of a rule change in terms of safety impacts, operating costs, travel times, environmental effects, or any other changes that might be relevant. Part of this work is engineering, but part of it is also economic and financial since it is necessary to predict the manner in which airspace users respond to a new rule. In an ideal world, the operational analysis would produce a neat report laying out in precise fashion a prediction of the changes that will result from the new rule. Unfortunately, the real world is not that simple. The operational analysis is the source of much of the uncertainty in the analysis of benefits. Dealing with the uncertainty in a prediction of, say, the number of lives saved over 10 years may turn out to be a significant issue when it comes to valuation of benefits.

Identification of Benefits

Identification of benefits may seem like a trivial task, but it is not. It is often the most demanding part of the work and one where major errors are easily made. It requires clear thinking about which effects of a rule are economic benefits and which are not, which different effects reflect the same benefit, and so forth. There is often confusion about precisely what is meant by "benefit" and related terms such as "social benefits" and "external benefits." Before proceeding further, there must be a clear understanding of the concepts underlying these terms. The most important point is the definition of an economic benefit.

A benefit is an effect that makes at least one person feel better in some way. In marketplace terms, all the goods and services that people spend money on are sources of benefit—food, clothes, shelter, entertainment, health care, and so forth. We know these things provide benefits because people willingly spend money to get them. Willingness to pay for a particular good or service is the same thing as a willingness to forgo other goods and services to obtain the one being bought. For the analyst, benefits from goods and services that are traded in the market are very convenient to work with since prices provide information about the level of benefits people experience. If a person pays $300 for a fancy food processor, we know that device provides the person with at least $300 worth of benefits.

Not all benefits are in the form of tangible goods and services, and not all benefits stem from marketplace transactions. For example, a person might pay a high

price for a house on a mountain ridge, not because it is a better house, but because he likes the view. This might be considered an intangible, but we know something about the value of the benefit because information is available on price of physically comparable houses in different settings. It is a different situation, however, if the government adopts regulations that reduce smog in some city so that people there have better views of their surroundings. There can be reasonable confidence that the aesthetic improvement is a benefit for most of the people in the city (some may not care), but there is little information on its value. The aesthetic effect is a benefit, even though its worth is unknown.

Perhaps the key characteristic of a benefit is that it has to be a benefit to one or more individuals in order to count. What matters is positive effects on people, not on governments or other institutions. For example, benefit to a firm is sometimes spoken of as a benefit. However, a firm, as such, does not incur benefits. Cost reduction for the firm counts because it turns into benefits for people, such as lower prices and increased output for the firm's customers and\or higher incomes for the firm's owners, workers, and suppliers.

Calculating the total benefits of a rule simply involves aggregating individual benefits. It is important to bear in mind here that these are *not* net benefits. A government intervention will have costs, and there will be losers as well as gainers. The result is total gross social benefits. The term "social benefits" is often used as if its meaning were similar to "external benefits," but this is incorrect and leads to a great deal of confusion. Whether a benefit is external or not does not really matter in benefit-cost analysis. Even so, there is still enough misunderstanding on these points to address them briefly here.

An external benefit occurs when an economic agent (a firm or a household) engages in an activity that generates benefits for others, but the recipients of the benefits are not obliged to pay for them.

The question of whether economic agents get paid for all the benefits they generate is not of concern. It is necessary only to make sure that they are accounted for, i.e., that societal accounting is thorough. In the case of noise reduction, for example, the fact that some or all of the benefit may be external to air carriers is irrelevant. The only things that matter are the degree of noise reduction effected by a rule and the value of that noise reduction.

It is useful, at this point, to make a summary note about terminology.

- Benefit—an effect that enhances the well-being of one or more persons.
- Social Benefit—the sum of benefits accruing to all persons from a particular effect.
- External Benefit—a benefit generated by an economic agent but accruing to persons other than the agent and for which the agent is unable to obtain compensation.
- Societal Accounting—taking account of all benefits related to some effect or activity, regardless of whether the persons experiencing benefits are directly involved in the activity.

Valuation of Benefits

Attempts at benefit analysis often fail when it comes to estimating a money value. This is true even when the first two phases of the work have been done well. The analyst can know the physical impacts of a rule with some accuracy and correctly identify those effects that are benefits and still come up empty-handed when trying to calculate a dollar value. This occurs most often when there is no market information, at least no direct market information, on how much a particular benefit is actually worth to people. In the context of aviation, this problem is most likely to come up in the case of environmental or health effects.

But serious problems of benefit valuation can arise for other reasons. The operational phase of the work may not result in a reliable point estimate of physical effects, and some way must be found to deal with the uncertainty in these estimates. There may be questions about the appropriate discount rate to use. There may be questions that do not have unambiguous theoretical answers. In general, the major issues in benefit valuation are something of a miscellany—some problems are theoretical, some empirical, and some a little of each. Their common element may be a lack of neat, clean answers.

IDENTIFICATION OF BENEFITS: SPECIFIC ISSUES

The October 1995 scoping session enumerated the following categories of benefits:

- Safety improvement,
- Operating-cost reductions,
- Environmental benefits,
- Health benefits,
- Savings in passenger time,
- System improvements,
- Public confidence, and
- Regional economic benefits.

Safety, Operating Costs, Environment, and Health

The first four categories on the list are unambiguously benefits and do not involve any significant theoretical issues. Basically, these are all cost-reduction benefits. Safety improvement reduces costs associated with accidents. Operating-cost reductions are just that. Environmental and health benefits are about reduced damage to the environment or to health.

There is a question about why health should be regarded as a category separate from environment. The issue is whether there are any health impacts of aviation apart from environmental effects or accidents. Effects on passenger health related to conditions inside an aircraft cabin might be a legitimate concern. If so, there is a case for listing health effects as a separate category, but it is a quite narrow classification.

Time Savings

Reduction of travel time is an unambiguous benefit. The biggest issue here is valuation. In terms of benefit identification, there may be an issue about whether small decrements in travel time should be counted as benefits. This is a question that has been debated extensively in the context of urban transportation; the preponderance of opinion among economists is that reductions in travel time definitely count.

The issue is at what point is a change in trip time so small that a traveler would be indifferent to it. In the context of aviation, the point is sometimes made that reductions of trip time less than 15 minutes do not matter to people on long flights. On the other hand, if one watches the behavior of people as they get off an airplane and try to get through an airport, one would conclude that passengers put a significant value on small units of time. If there is a threshold below which time reductions do not matter, it would be hard to establish with any degree of certainty.

There is no doubt that people value reliability in trip times. More precisely, they value not being late. They rarely object to being early. Any reduction in average lateness of arrivals would be an unambiguous benefit. Trying to establish a minimum level below which time reductions do not count does not appear to be a useful effort. FAA would be well advised to follow the practice of counting small reductions in time, as long as it can be reasonably certain that they are genuine.

System Improvements

In the scoping session this category was suggested as a kind of catch-all grouping, a category into which to put effects that one cannot be certain to how to label. This vagueness renders it virtually useless for analytical purposes. The apparent intention was to capture the effects of technological or operational improvements that might result from FAA rules. Such improvements cannot be analyzed as economic benefits, however, unless the impacts can be traced through and shown to have an effect on carriers, customers, or others in terms of safety, operating costs, time, the environment, or something else that clearly enhances well-being. Simply saying that the system is "better" is not enough There has to be a fairly clear idea of the way in which it is better before it can be meaningfully analyzed.

Public Confidence

This is another category that was put forward at the scoping workshop without very precise definition. The concept of public confidence was raised in the context of a discussion about catastrophic crashes. It is a fact that a crash resulting in the loss of dozens or hundreds of lives will rivet public attention and raise concern over safety of air travel in a degree entirely disproportionate to the objective data on the safety of air travel compared with the safety records of other modes.

In reflecting on this phenomenon, two points regarding benefit analysis appear. One is that there may be costs associated with deaths in a major crash that go beyond the victims and their families and friends. It may be the case that a great many people experience emotional pain, some form of grief, on hearing of a major catastrophe, even when they have no direct personal connection with it. Perhaps this effect can be called "public grief." The reduction or elimination of such grief would be a benefit of any rule that reduced the frequency of major crashes, a benefit additive to the benefits of reducing death, injury, and property damage.

It may well be true that most people intuitively exaggerate the risk of air travel. To the extent this is true, improved information on safety and enhanced public confidence are the same thing. In principle, however, they are not the same thing. Better information on safety, or any other aspect of air travel, is a benefit, regardless of whether the better information raises or lowers a person's valuation of air travel.

Regional Economic Benefits

This is another benefit category that suffers from a lack of conceptual clarity. In discussions about the impacts of transportation improvements, regional economic effects are often talked about, but less often defined with the rigor needed for economic analysis. Regional effects are

usually discussed in the context of a transport investment (e.g., a new or expanded airport or highway) that improves access to some city or region. Improved access means the cost of getting people and goods to and from the region is reduced in time or money or both. It is often thought this will lead to an increase in economic activity within the region, and it may well do so.

Assuming these expectations are actually realized, a major pitfall for the benefit analysis is the location effect. If firms decide to conduct activities in the region that they would have conducted elsewhere in the absence of the access improvement, there is no national economic change. Gain in one region is a loss in some other.

The lowered access cost can, however, result in real economic gain. The improvement in access means reduced costs for those who ship into or out of a region. A manufacturer in the region will experience a reduction in the cost of products delivered to customers in other regions. Part of the cost reduction will be passed forward to consumers in price reductions. There will be some increase in total production and some increase in the consumer surplus in the product. Manufacturers might use part of the transport cost reduction to sell to a wider market area.

Revised Benefit Categories

On the basis of the preceding discussion, it makes sense to revise the benefit categories as shown in the following table.

Scoping Workshop	Suggested Revision
Safety	Safety:
Operating costs	Death
Environment	Injury
Health	Property damage
Travel time	Public grief
System improvements	Operating costs
Public confidence	Environment
Regional economic benefits	Passenger health
	Travel time
	Information
	Productivity

In the revised list, system improvements have been discarded as a category. Productivity has replaced regional benefits. Public confidence has been redefined as information, and public grief has been added to the safety effects. (The list of safety effects has been inserted to make this point clear.) Health has been redefined as passenger health to make a clear separation from environmental effects.

VALUATION OF BENEFITS: SPECIFIC ISSUES

The valuation issues raised in the scoping session were mixed—some applying to several benefit categories, some specific to only one. This is the nature of valuation questions; they range from practical engineering matters to some of the more arcane realms of economic theory. As noted at the beginning of this paper, operational and engineering questions are likely to be significant issues for accurate valuation, even though they have nothing to do with economics. Indeed, the most important problems FAA has to deal with are concerned with accurate estimates of savings in operating costs and time and how to deal with uncertainties in those estimates.

Issues by Benefit Category

Safety

FAA has well-established procedures for assigning money values to death, injury, and property damage. There do not appear to be any strong reasons for revisiting these issues here. The concept of public grief, the emotional pain that many people may feel on learning of a catastrophic accident even though they have no direct connection with it, is suggested here as an addition. This is the kind of effect for which contingent valuation is sometimes used, but there are very serious weaknesses in this technique. Valuation of public grief presents horrendous problems, and there is no obvious answer as to how to treat them.

Operating Costs

If the operating cost reduction is known, valuation is—up to a point—straightforward. The operational work is a big part of the valuation task, and the whole of the cost reduction is a benefit. Significant uncertainties in estimating the cost reductions may be unavoidable. If cost reduction leads to lower prices for air travel, there will be some additional benefit in the form of consumer surplus from increased air travel. It is necessary to know the appropriate demand elasticity to value this effect.

Environment

Noise, air pollution, and depletion of upper-atmosphere ozone are among the effects to be considered. Each

presents different valuation problems. There is an extensive literature on noise costs and on the health costs of air pollution, much of it developed in the context of urban transportation. Many experts have offered various estimates of dollar costs per decibel and per ton of hydrocarbons (HC) and oxides of nitrogen (NO_x). Nonetheless, there is still significant controversy about these estimates.

In regard to noise, some work has been done on the variation in real estate values associated with changing noise levels. One approach, for example, is to compare prices for comparable houses inside and outside the noise contours of an airport or before and after a change in noise levels. Efforts to find a surrogate (or "shadow") price of noise in property-value changes come under the heading of hedonic pricing. (See the more general discussion below.) The usual criticism is that statistical analysis of changing house prices has failed to control for all relevant variables and so does not properly isolate the effect of noise changes from other factors that also drive property values. Whatever the merits of hedonic pricing may be, noise is surely going to be a major issue in valuing FAA rules. Research on the valuation of noise costs is needed.

Valuing the health effects of air pollution presents complex and difficult problems. It may be that aviation's biggest impact on air pollution (although rather small in absolute terms) is the emission of NO_x, one of the precursors of ground-level ozone. The marginal impact of an extra ton of NO_x on ozone formation varies greatly with time of year and with place. In many localities, the marginal effect of more NO_x may be zero or it may even reduce ozone formation. There has been extensive and fairly good research on the health-damage costs of ozone, but strong controversy remains. The same can also be said for particulate matter.

Before FAA undertakes any extensive research in this area, it should first try to determine whether aviation has much of an effect on ozone formation, emission of particulate matter, or any other air pollutant. Some studies suggest that the contribution from aviation is so small that measures for controlling emissions from aircraft would have little or no effect on health. This is the first point for FAA to address. With regard to effects on upper-atmosphere ozone, the major question at this time is whether aviation has any such effect to a significant degree. Until this issue is resolved, there is little to be done with regard to valuation.

Passenger Health

The first question here is what impacts on passenger health might stem from FAA regulation. Much of the evidence is anecdotal. The big problem is likely the operational one, working out what the health effect of a regulation would be. The valuation issue is similar to the one for air pollution. There is a growing literature on the money value of health effects. If passenger health turns out to be a significant issue, FAA needs to gain some familiarity with the issues and controversies in the current literature before deciding what else to do.

Time

The paramount issue here is the operational one. FAA would have to develop good estimates of time savings that would flow from a new rule and be able to express it as reduction in trip time for an average trip (or across a distribution of trip lengths). FAA also has to be able to calculate the impact of trip-time reduction on carriers' operating costs and equipment requirements.

With the very extensive work that has been done on the value of time for travelers, it is not immediately clear that FAA needs or would want to initiate new research in this area without clear evidence that the current estimates of the value of passenger time are inadequate or insufficient. This is a case where sensitivity analysis would be quite useful. If FAA were uncomfortable with choosing a point estimate for the value of passenger time, the alternative would be to choose a range of values.

Information

Attaching a value to improved information about aviation safety appears, at first glance, to be extremely difficult. One approach would be to try to determine (possibly through surveys, focus groups, or other such techniques) how many people actually choose not to make trips by air because of an exaggerated perception of risk. It might be possible to work out the average cost, in terms of time and money, of traveling by an alternative mode or the benefit lost by giving up a trip altogether. Finally, and perhaps most difficult, one would have to develop an estimate of the degree to which these perceptions could be affected by FAA regulations. Perceptions of the risks of air travel may well have emotional or psychological roots on which FAA rulemaking will have little effect.

Productivity

Among the valuation problems discussed here, this is one of the most difficult. Assume that a new regulation reduces travel and shipping costs for firms. While it maybe possible to estimate the cost reduction, there is really no way of going from that first-order effect to secondary productivity effects that could flow from changes in the way business is conducted.

A plausible approach to this question is statistical analysis of macroeconomic data in which productivity changes are compared with investment in transport infrastructure. It is reasonably clear that it takes major network effects to achieve a noticeable impact on national productivity. Thus, it may be a severe problem in terms of scale. Not many FAA rules are likely to have the kind of impact that could be detected and isolated in macroeconomic data.

Without question, gains in productivity could stem from rulemaking, and some of these gains might be measurable at the level of a firm or a region. The difficulty is predicting the secondary productivity effects that could stem from a first-order cost reduction.

General Issues in Benefit Valuation

The following general issues are important:

- Hedonic pricing and contingent valuation,
- Sensitivity analysis,
- Discount rate, and
- Valuation of existing capital.

Hedonic Pricing and Contingent Valuation

These are two quite different techniques for solving the same problem. How do you find out what people would be willing to pay for a given benefit in the absence of direct price information from the market? With hedonic pricing, analysts seek to answer this question by examining indirect information from the market—for example, to see how real estate values have been affected by airport noise levels. With contingent valuation, the answer can be sought through opinion surveys that ask people how much it would be worth to them to make airport noise go away.

The great weakness of contingent valuation is that people's statements about what they would be willing to pay may not, in the absence of market discipline, mean very much. The signal a person sends by offering his opinion on the value of something, when, in fact, he does not have to give anything up, may be quite different from the signal he sends when he actually has to pay. When a person pays for something he makes an implicit decision not to pay for something else. All budgets are finite. Purchasing a given bundle of goods and services in the market means not purchasing some other combination of goods and services. In order to get certain benefits, the consumer must forgo the opportunity of getting other benefits. An opinion about what a person is willing to pay for something that is not subject to the discipline of actually giving up something else is not, in the view of a great many mainstream economists, worth very much as a measure of value.

Experiments in which one group of people have been asked what something is worth to them without having to pay while another group is asked the same question in a context where they have to pay have shown wide disparities in the responses. On the other hand, contingent-valuation surveys have yielded fairly accurate answers when people are asked questions where they have market experience and market information. There is also evidence that contingent valuation provides useful information on people's ranking of various effects. While contingent valuation gets good results in these respects, it is not much help with the problem of money valuation in the absence of market information. Many economists are skeptical of contingent valuation because the answers are not subject to market discipline. It tends to find favor with some economists and with environmentalists and trial lawyers because it may be the only source of numeric values for some effects (or, some would say, a convenient source of high numbers).

Hedonic pricing is, conceptually, on sounder ground than contingent valuation. It seeks answers about value from market signals. The great difficulty with hedonic pricing is empirical. Taking the example of house prices and airport noise, it is necessary to make a statistical analysis in which all effects other than noise are properly treated in the regression so we can isolate the noise effect. As a practical matter, this is hard to do and especially hard to defend. Critics can usually find grounds to quarrel with the way in which some key variable was treated.

Thus, the two alternative approaches are noted more for their weakness than their strength. Contingent valuation is conceptually weak because it tries to arrive at conclusions about value on the basis of signals that are not subject to market discipline. Hedonic pricing is empirically weak because of the difficulty of trying to isolate the effect of a single variable on demand for a good. In considering this choice, it might be best to choose an approach where the conceptual foundation is solid and try to find ways to deal with the practical problems of the statistical analysis. One such approach would be to use sensitivity analysis around statistically derived values.

Sensitivity Analysis

There is nothing mysterious about sensitivity analysis. It is a simple method for dealing with uncertainty in an estimate by using a range of values for a given variable and noting whether varying the value over that range has

much of an effect on the outcome of the analysis. Consider, for example, a proposed rule where time saving is an important benefit. Use of a range of values of time could supply two important pieces of information. If the benefit-cost analysis yields a favorable result for the rule even when the lowest value of time is used (or an unfavorable result when the highest value if used), uncertainty about the value of time is not a problem in the analysis. If the sensitivity analysis shows there is a point on the range where the outcome of the analysis changes, it is necessary to make a judgment about what the value of time really is and how much confidence can be placed in that judgment.

Sensitivity analysis has been, and should be, a valuable and frequently used tool for FAA in regard to issues such as the value of time, the cost of noise, and the discount rate. It should also be used where there is uncertainty about the operational effects of a rule in terms of safety, operating costs, and time savings.

Discount Rate

Since BCA is carried out on a present-value basis, it is necessary to use a discount rate in order to bring future values of benefits and costs back to present values. BCA was developed for evaluation of large infrastructure projects with a big up-front capital expenditure and a long stream of benefits out in the future. For this purpose, many economists argue that the right discount rate is the opportunity cost of capital, i.e., what the capital could earn in alternative uses. But there are people who will argue that, for public investments, the discount rate should have something to do with the government's borrowing rate. In the case of FAA regulations, public investments do not come into play, but it might be necessary to look at government rules that require private investments.

In cases that do not involve up-front investment, it might be argued that future consumer benefits such as time savings or reductions in noise levels should be discounted at the consumers' marginal rate of time preference (the rate at which an individual values future consumption against present consumption). There is a fringe group of economists, with ties to environmentalists, who argue that future benefits should not be discounted at all because it is unfair to future consumers to place a low value on their benefits.

The question of which discount rate to use has been argued for a long time and will probably continue to be argued as long as there are at least two economists left walking the earth. In a world of scarce resources where priorities must be set, FAA would be well advised not to venture very far into this quagmire. As a practical matter the best course is surely to follow OMB guidance on the discount rate and use sensitivity analysis if, for any reason, FAA feels uncomfortable with OMB's recommendation.

Valuation of Existing Capital

In the October 1995 scoping workshop this issue arose in the context of a rule that would render existing capital equipment, such as aircraft, obsolete. It might be the case that a carrier would find that aircraft with 15 years of economic life remaining under existing rules are no longer usable under the new rule. The real question is how to treat the cost associated with the remaining economic life that disappeared. It was suggested that loss of the revenue that would have been generated in those 15 years would be one answer to this question.

This is a case where the answer is straightforward. The obsolete aircraft represent a sunk cost; their value does not matter. The cost to the carrier, and to society, is the cost of replacing them earlier than would otherwise have been the case. If, in the absence of the rule, the aircraft would not have been replaced for 15 years, the cost is the difference between the capital for buying the replacements now and the present value of the same capital 15 years into the future.

Loss of revenue does not bear on the situation; there is no loss of revenue. What changes is the equipment the carrier uses to generate the revenue. The only way the carrier would lose revenue because of the rule would be if it did not replace the obsolete equipment. But it would still not be a cost to society if the traffic in question went to other carriers.

PRIORITIES

It may be useful to offer some thoughts on where the foregoing discussion leads in terms of research priorities for FAA. First, it seems clear that some benefit categories are more important than others in terms of their likely impact on the net benefits of FAA rules and the likelihood of gaining useful new knowledge. The following is a list of the highest priority benefits:

- Safety (death, injury, property damage),
- Operating costs,
- Travel time, and
- Noise.

Public grief is not included in the safety category here. Its reduction would certainly be a benefit, but it might not be a very big one, and establishing the

credibility of value estimates associated with it is likely to be quite difficult. Air pollution is not included because the marginal effects of air pollution are quite small. With regard to passenger health, information, and productivity, the impacts are likely to be small and valuation problems great. These are interesting areas and they deserve some attention, but they are not at the top of the list.

In terms of research, the following are of the highest priority:

- Operational work on operating cost and time effects,
- Statistical work on hedonic pricing of noise effects, and
- Estimates of the impact of aviation on the health effects of air pollution.

FAA's most important task is to develop accurate estimates of the actual impacts of rules on operations and modes of conducting business, especially rules introducing significant new technology. Noise is going to be an important factor, and FAA research could make an important contribution. Even if aviation proves not to be a significant factor in the areas of air pollution and health, FAA should at least become acquainted with the current work on health costs and air pollution.

PREPARED RESPONSES

Two participants in the workshop, Douglass B. Lee of the US DOT Volpe Center and Gerald Kraft, an independent consultant, were asked to review the paper authored by Mr. Beshers and prepare brief written comments and general observations on benefit analysis. Their remarks are presented below in summary form.

Mr. Lee's comments indicated general agreement with Mr. Beshers's view, but he approached the question of benefits with a slightly different emphasis. He also advanced an argument for considering a third type of impact—transfers—which are neither benefits nor costs but a matter of equity. The principal focus of his remarks was on issues of equity and how to incorporate them in benefit-cost analysis.

Mr. Kraft concurred with the views of Mr. Beshers and Mr. Lee and directed his remarks to several practical concerns, such as BCA methodology, models of consumer behavior, and questions of how to interpret the outcomes of BCA. He concentrated on three dimensions of BCA methodology: categories of benefits, valuation of benefits, and analysis of benefits.

COMMENTS BY MR. LEE

Terminology

In order to conduct benefit-cost analysis (BCA), there must be at least two alternatives, one of which is referred to as the base alternative. The base is defined to be the most likely future state if the proposed action is not taken (the "without" case). All impacts are measured as differences between the base and the action alternative. Impacts can be classified into three categories: costs, benefits, and transfers.

Costs represent the value of resources used up by an alternative, compared to what they would have been used for in the base case. For investment BCA, costs are typically initial capital expenditures. For regulatory evaluation, costs may include agency costs and perhaps compliance costs; otherwise these impacts are grouped with benefits. It does not matter whether an impact is classified as a cost or benefit so long as the arithmetic sign is correct. (For some purposes, namely, when using a benefit-cost ratio to choose a subset from among feasible projects, the classification of costs makes a difference. See the discussion related to the criterion.)

Benefits are all other impacts that have value to society as a whole, meaning that some resource is saved or consumed as a consequence of the action. (It does not matter whether the impacts are external or internal to markets, so long as they are not counted more than once.)

Transfers are all impacts that are neither benefits nor costs. Money payments in the form of fees or taxes, changes in the prices of goods and services, and changes in the value of assets amount to transfers. The net (sum) of all transfers is the net benefit of the action. Measuring all transfers and summing them, however, is not a feasible way to estimate net benefits. Rather, the components of costs and benefits can be disaggregated into groups that gain or lose. Scitovsky labeled price effects "pecuniary externalities," and concluded that they are not externalities. Most indirect effects are pecuniary, and therefore transfers rather than benefits.

The criterion for efficiency is maximum net benefits, i.e., the difference by which the total value (present or annualized) of incremental benefits (relative to the base alternative) exceeds total costs. Feasible alternatives are those with positive net benefits (net benefits > 0), which is the same threshold criterion as a benefit-cost ratio greater than 1. The benefit-cost ratio is typically used to select a subset of feasible projects when some category of costs is constrained, most commonly those for initial capital expenditures.

Travel Time Savings

The valuation problem with time savings has nothing to do with the magnitude of time savings per passenger trip (a minute is 1/60th of an hour just as one penny is 1/100th of a dollar), and everything to do with the nature of the block of time to which the increment of savings can be added. If the traveler can leave later to arrive at the same time, the savings should be valued at leisure or sleep time value. Some travelers at the margin might even avoid an overnight stay. If the savings are consumed sitting in a departure lounge rather than on an aircraft, the difference in opportunity value (between base and action alternatives) of the time is small. If the traveler arrives early for an appointment, the savings may have less value (per hour) on average than work time. Thus, it is apparent that the reliability and form of the time savings are more important than their average or expected magnitude.

System Improvements

Benefits or improvements not elsewhere classified amount to an expansion of capacity or other quality improvements

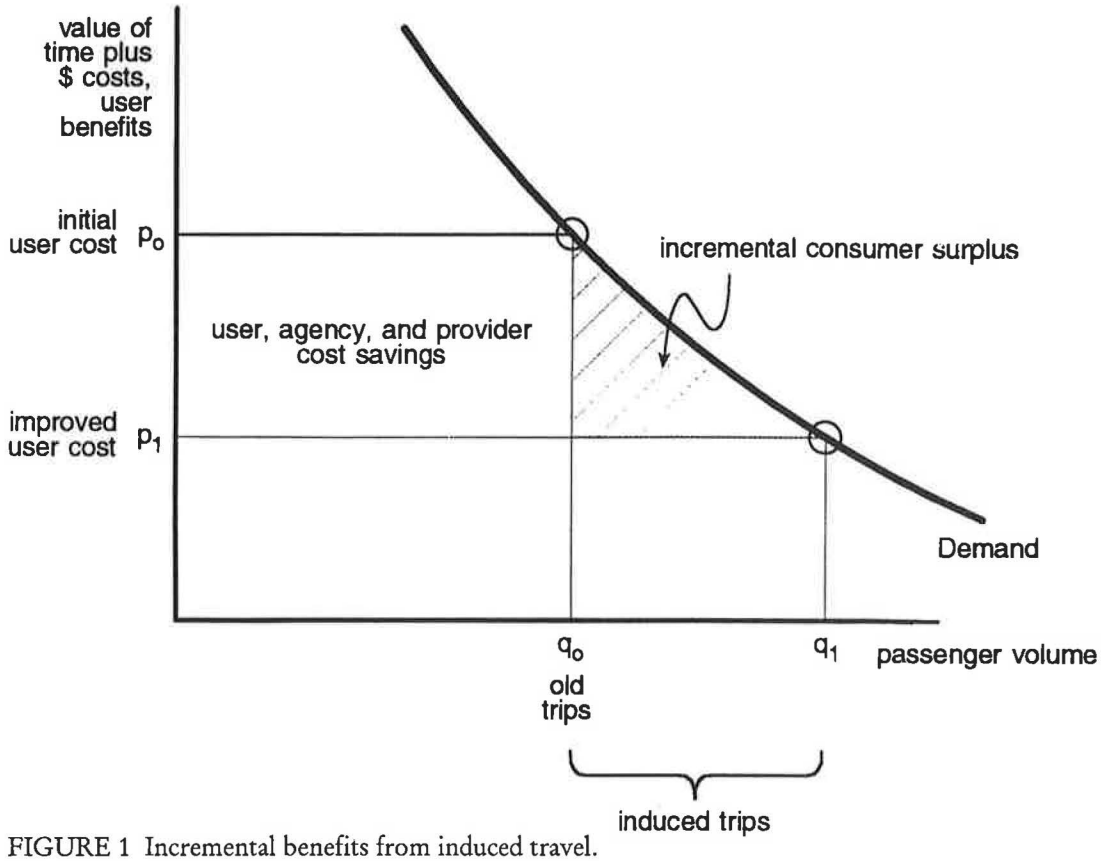

FIGURE 1 Incremental benefits from induced travel.

that result in a higher willingness to pay for the same output. Such improvements add to consumer surplus. It is preferable that such changes be modeled as movements along a demand curve (i.e., additional travel as shown in the diagram) rather than as shifts in the demand curve at the same output. Notice that externalities do not enter into the estimation of induced travel because they are not included in the price to the user.

Many benefits can be taken in a variety of forms, e.g., as accident reduction or as a capacity increase. For BCA purposes, the most likely adaptation to the improvement should be the one used, e.g., maintaining the same accident risk while increasing output by reducing peak aircraft spacing.

Public Confidence

An increase in public confidence, *ceteris paribus* (i.e., nothing actually changes), is like advertising in that it results in a higher willingness to pay at each output level (meaning a shift in the demand curve) and therefore some additional consumer surplus. If public confidence means perceived safety, anxiety while traveling, or while loved ones are traveling, is reduced, along with the opportunity cost of the travel time.

Consider two cases: 1) the traveler makes "better" choices about the amount and mode of travel, and 2), the traveler makes "worse" choices. In both cases, information is being acquired by consumers. Assume, for the moment, that the information is costless. Then "better" means that travelers more accurately perceive the attributes (e.g., risk) upon which their choice of travel mode and quantity are based, so they enjoy more consumer surplus. "Worse" is the opposite. So long as travelers are rational, their choices are based on the information they have. They either get more accurate information or they are deceived.

If information is not costless, there is a trade-off between the cost of information and better decisions. Information acquisition is a transaction cost and leads to better decisions if the price of the information can be reduced to the consumer. Transaction costs, however, are like any other market good for which the consumer decides how much to purchase based on internal benefits. If the consumer is assumed to make rational decisions and chooses not to incur the costs of additional information, there is no reason to intervene unless the government can

supply the information at lower cost than any potential or actual private supplier.

If, on the other hand, consumers are *not* rational, the burden of analysis is even greater. Information then becomes a "merit" good, serving to induce consumers to behave in their own best interests despite their irrational desires to do otherwise. Overruling consumer sovereignty requires having a comprehensive utility function that substitutes for the consumers' own valuation and determines whether consumers are better or worse off for being induced (or required) to change their behavior.

Thus, the question of public confidence benefits can be translated into two other questions. First, if consumers are rational, why should they be provided with additional information they have not been willing to pay for themselves? Second, if consumers are not rational, how can one tell whether a change in their behavior will make them better or worse off?

These efficiency questions are not rhetorical. It is possible to answer them satisfactorily, but the constraints imposed by the questions do not leave much room to argue for public confidence as a benefit above and beyond the benefits previously enumerated (safety, operating costs, environmental, health, travel time, and additional trips).

Alternatively, if "public satisfaction" is the willingness to spend tax money on collective goods that give taxpayers satisfaction, this is expressed through the political process and is not subject to technical analysis. It is not the role of BCA to second-guess the political process by estimating how much it would be willing to spend. Rather, BCA should be informing the political process of how much real benefit the spending of public funds would generate.

Regional Economic Benefits and Productivity

Impacts of changes in one market on other markets are indirect effects and largely pecuniary, i.e., transfers. While it may be of some interest to estimate how costs and benefits ripple out, the magnitudes of the ripples do not change the sum of costs and benefits. Productivity in the market of interest (air travel) is accounted for in operating costs, time savings, and additional output. Productivity changes in related markets are passed along through market processes and are transfers.

To the extent that synergistic impacts reinforce or stimulate innovation and new activity and result in additional demand for air travel, long-term feedback effects can be captured through improved demand forecasting techniques. Thus, there is a need to incorporate explicitly long-term impacts into the demand estimates, but there is no need for a category of benefits that comprises indirect economic impacts.

Suggested Format of Costs and Benefits

The table below summarizes the conclusions of the above discussion.

Regulatory Costs and Benefits

Cost Category	Benefit Category
Operating Costs (agency)	Travel Time
Compliance Costs (private)	Safety
	Environment
	Health
	Induced Demand*

*Value of additional output measured as incremental consumer surplus.

New Technology

Technology is a generic term for the stock of available production functions (the processes by which labor, materials, and other inputs are transformed into desired outputs). Economics generally treats technology as given, i.e., exogenous. Technology can and does change, but it cannot be predicted and is difficult to measure in the aggregate. Changes in technology and innovations occur spontaneously and are stimulated or encouraged by market opportunities and government regulation.

Evaluation of new technology involves estimating its costs and benefits. If the technology is still to be developed, its costs include development as well as deployment. If the technology has been fully developed, costs refer only to acquisition, installation, and perhaps operating costs. The benefits of new technology lie in the ability to produce something that was unreachable before or to produce something at lower cost. When something can be produced at lower cost, it typically prompts a change in the input mix (more of the now cheaper input) and perhaps a change in the output mix or output attributes (e.g., higher output *and* greater safety).

Cost savings are readily incorporated into BCA, to the extent they can be predicted. The costs of regulatory compliance, for example, might be expected to decline from current levels as technology evolves in response to competitive pressures. Technology that allows for increased output is difficult to value because induced

demand results in consumer surplus, the value of which is more ambiguous than cost savings. Greater comfort depends upon users' willingness to pay. Safety improvements can be converted into capacity expansion and delay reduction. There is no direct way to value technology *per se*, but with skill and insight it is possible to translate the impacts of technological change into real benefits.

The Global Positioning System, for example, allows the phasing out of an existing obsolete navigation system (thereby producing cost savings, if redundant systems are eliminated), greater precision in poor weather (safety/capacity improvement), and universal standardization (all of the above).

New BCA Methodology for Benefits Valuation

The theory for measuring benefits is well established, but not widely known or understood in practice. Methods for applying this theory have been developed for numerous contexts, and more will be developed in the future. Valuation of benefits such as reduced noise, reduced pollution, reduced travel time, reduced opportunity cost of travel time, and consumer surplus has been done for a long time, but the methods can be greatly improved. Improvement comes from accumulating previous wisdom and experience and expanding it carefully at the margin. It should be a continuing effort focused on the specific context, FAA regulations in this instance.

Sensitivity Analysis

Testing the impacts of plausible ranges of parameter values is a natural analytic activity and requires no special knowledge to conduct. Discount rates of 4, 7, and 10 percent, for example, cover a generally accepted range for testing that parameter. Variations in the valuations of life and travel time are likely to be quantitatively significant. Highly structured, formal sensitivity analyses are seldom required or even helpful. The relationship between uncertainty in inputs and uncertainty in conclusions can be explored and explicated by further research, with the purpose perhaps of codifying some rules of thumb and alternative procedures for conducting such analyses.

Hedonic Pricing

For values of attributes that cannot be traded separately in markets, quantitative estimation can be accomplished using econometric and statistical techniques based on revealed preferences for goods with and without the attributes of interest. Airlines might do this to compare, say, designer seats versus frumpy seats. How the FAA might use hedonic pricing to value its regulations or their attributes is less obvious.

Contingent Valuation

An alternative method for valuation of attributes uses stated preferences, obtained through focus groups, surveys, or clinical simulations. Such instruments have even been used to estimate the existence value of resources not consumed by the user (e.g., bald eagles). Application of these methods requires care, skill, and a measure of common sense.

Changes in the Value of Existing Capital

Capital assets (lifetimes less than one year) are valued on the basis of the benefits they are expected to produce in the future, in their best *ceteris paribus* use. In markets, this valuation is the capitalization of the future net income stream. As the world turns, markets shift, government regulations are strengthened or relaxed, populations grow or decline, tastes change, and so on, the market value of existing capital shifts correspondingly to represent the future demand for the asset.

Such shifts in value are transfers. Some owners of capital gain at the expense of others who lose. The economic base of a community shrinks, and the price of houses falls, while in the growing community the price of homes inflates.

An example is the value of "noisy" aircraft after a noise regulation is imposed (or announced, or anticipated). Owners of noisy aircraft suffer a loss in net worth, while owners of quiet aircraft gain. If there are not enough quiet aircraft to satisfy demand, owners of equipment that manufactures hush kits and quiet engines also gain. If demand is stimulated for more capital equipment to manufacture engines, owners of such capital also gain. If the demand for replacement engines grows, owners of all capital inputs, such as engineering expertise (human capital), raw materials (iron ore, limestone), and materials processing (casting furnaces, crawlers, bulk ore ships), are potentially affected.

The net of all these transfers in this instance is essentially zero because the benefits of the regulation are captured by land owners near airports while the costs are borne primarily by airline passengers and shippers. Land use impacts are capitalized into land rents, while the incidence of higher transportation costs is widely diffused;

and neither one affects the types of capital affected by the demand for quiet aircraft.

An example on the benefits side is the redistribution of land values resulting from an improvement in surface transportation. Locations where access is increased gain at the expense of locations where access is not increased and where attributes are otherwise unchanged, except possibly for taxes imposed to pay for the improvement. Again, these are transfers. Since they capture the time and user-cost savings from the transportation improvement, land values will increase by approximately the amount of the net benefits of the improvement, whether positive or negative. These are not additional benefits, of course, but user benefits passed on to landowners.

This illustrates, however, the usefulness of providing information about equity or distributional impacts of a regulation along with the benefit-cost evaluation.

Equity Impacts

Transfers, or equity impacts, are (for analytic purposes) "orthogonal" to efficiency impacts, meaning they describe a different dimension. Although the analysis of equity impacts at the project or regulatory level is rarely practiced and even less well understood than efficiency impacts, such analysis has much to recommend it. It makes the evaluation comprehensive, in that all impacts of interest can be included and the choice is whether each item belongs in the efficiency or equity category. It helps to inform political debate by identifying those who gain and lose, paving the way for compromise. Equity is a valid basis for evaluating projects and regulations, but it should be kept separate from, and not confused with, the efficiency evaluation.

Empirical methods for equity analysis are somewhat less developed than those for efficiency, and quantification is more difficult because the information is more finely disaggregated. Even so, useful, and often reassuring, conclusions still can be obtained.

COMMENTS BY MR. KRAFT

FAA is to be congratulated for embarking on this road to improving the analysis of costs and benefits associated with regulations. The regulatory reform movement has demanded that government agencies account for costs and benefits in their rulemaking. There has long been a tradition to measure the benefits and costs of government activities. This has not always been done with the kind of rigor one might wish. In the charge to TRB, FAA recognizes the need for continual development of measurement techniques and a better understanding and knowledge of the impacts of regulatory acts. This type of activity with TRB represents a major step in continuous quality improvement.

The comments provided here deal with issues identified by the October 1995 scoping session and those raised in the paper by Mr. Beshers. Specifically, these remarks pertain to categories of benefits, valuation of benefits, analysis of benefits, and other aspects of the problem that should be taken into account in structuring a systematic approach to BCA.

A General Approach to Benefit-Cost Analysis

It is useful to look at how benefit cost analysis might be applied to changes in rules and regulations. Without defining a specific methodology, there are some general tasks that need to be accomplished. Considering them will set the stage for determining what measurements are needed and how to apply them.

- Most important, sound application of benefit cost analysis should be based on a well-developed methodology that allows all situations to be measured consistently.
- There should be a standard set of issues to consider. The categories of benefits developed at the scoping workshop and discussed in Mr. Beshers's paper are a very good start.
- It is necessary to define the interest groups upon which impacts will fall.
- Where possible, there should be sets of parameters or little models to describe qualitatively and quantitatively the impact of an action for each category of benefit and for each interest group. How will a new rule affect the group? What dimensions are affected? Consistent measures are needed to compare alternative actions. This is not to say that models or parameters should be adopted once for all time; there can be changes as the need arises. On the other hand, it does not seem reasonable to use an entirely new or different approach for each possible new action. Certainly not if alternatives are being compared.
- Where impacts were not originally measured in economic terms, some valuation of the physical impacts has to be performed.

This brief outline of the process of benefit-cost analysis helps to point out some of the needs that have to be satisfied to do a sensible analysis.

Regulations often have overlapping effects. Care must be taken to count benefits only once. When facing a menu of changes, the question is which ones to

implement. The sets of possible changes generally have overlapping impacts. If one change is made, the benefits and costs of other changes may be affected.

There are costs to the government to develop, introduce, implement, and enforce the new rules. There is likely to be some budget constraint on the sets of possible regulations that can be adopted. Proper maximization of the net benefits subject to a budget constraint requires a search through all possible combinations of changes for which the budget constraint is satisfied. The items in the combination will determine the benefits derived. Thus, selection may require a multinominal programming approach, making BCA analysis very difficult. As a practical matter, it may be necessary to live with approximations.

Regulations and Investments

The emphasis in this workshop is on regulations and not on investments. Benefit-cost analysis is most useful in selecting one particular regulatory approach from among a set of alternatives. The introduction of new technology by investing in new equipment generally leads to accompanying changes in rules. A regulation may be a substitute for an investment in equipment. For example, rules for spacing aircraft are highly dependent on the ability of controllers to identify and communicate with aircraft displayed on radar screens and to track them. The absence of radar screens would require pilots to continually report milestones along the flight path so that safe spacing from other aircraft can be maintained. Thus, improved equipment permits reduced spacing between aircraft without compromising safety. This example shows that often there are important trade-offs between investments and rules.

The basic principles of doing the benefit-cost analysis are the same for both the investment and regulation. In both cases there are generally associated operating costs. The investment does, however, have an additional dimension, the cost of long-lived equipment that must be acquired and maintained.

Segmentation

Interested groups of the population must be segmented in ways that will help to measure and value benefits and costs. The background materials furnished for this workshop seem to focus implicitly, and at times explicitly, on commercial airline passengers and operations. This would suggest that the important segments are airline passengers, airlines, airline employees, and ground support personnel at airports or in the air traffic control system.

Even this group of interested parties should be divided. Passengers need to be divided into business and nonbusiness travelers. The values of travel for these two groups are often very different. Airline operations can be divided into short commuter flights, intermediate stage lengths, and long-haul carriage. In addition to commercial passenger transportation, freight and express operations must be considered. The methodology and parameters for the freight segments of the market are very different from those for passengers. Some rule changes may have little or no impact on some segments but major impacts on others. The possible effects, both direct and indirect, on each segment must be considered. Regulations directed at one segment of the market may produce secondary effects, negative or positive, on other segments. Curfews imposed to abate noise will have impacts on freight and express services that are very different from those on passenger carriers since the former are very dependent on late night and very early morning flying.

FAA regulations extend far beyond commercial passenger and freight. General aviation is a diverse segment that includes corporate jets, weekend recreational flight in small single-engine aircraft, heavy-construction helicopters, and training flights with practice stalls and touch-and-go landings. FAA also regulates other activity in the airspace, such as gliders, balloons, blimps, parachutists, and sky divers. FAA regulations affect all airspace users one way or another. But FAA regulations do not stop at flight activity. There is regulation of pilots covering training, medical status, and certification. How do we measure the costs and benefits when FAA changes a rule that might result in a pilot failing to pass his medical the day after he purchased a $100,000 airplane?

Other regulations deal with ground installations (radar and navigational aids), airports, landing systems, and lighting for high obstacles. FAA regulates the mechanics who work on aircraft. Aircraft and equipment must meet standards set by FAA.

Each new regulation requires examination of the impacts on each segment. By segregating the interested parties into carefully defined segments, it is possible to develop approaches for measuring impacts. Interdependence must be considered. A regulation that leads to more air travel is also likely to increase the number of aircraft, the use of certain airports (perhaps straining capacity), the number of mechanics, the number of pilots, and so forth.

The General Evaluation Problem

Clarity is needed in the area of costs and benefits. While it is possible to draw an arbitrary line between costs and benefits, it may not useful. A rule that reduces the operating costs of an airline is a benefit. A rule that

increases the operating costs of the airline may be a cost or a negative benefit. When the ratio of benefits to costs is used as a measure for comparative purposes in selecting rulemaking actions, defining what is a cost and what is a benefit becomes extremely important. Categorizing a cost as a negative benefit results in a different ratio from categorizing it as a cost.

The present value of the net benefit stream is the only way to evaluate new rules. It avoids the need for precise categorizations of costs and benefits and all the problems created by the ratio approach. It also avoids the problem of rejecting projects with very high benefits but also very high costs because the ratio is too low. It may nevertheless be true that the maximum net benefit can result from the very expensive project.

Valuation of Benefits

With regard to the discount rate, use of a realistic national standard, perhaps set by some government agency, may be a good approach. Because some costs are financed by funds derived from the private sector, some consideration should be given to the value of money in the private sector. Taking away dollars that might earn 10 percent at the margin in the private sector for a public project that yields 7 percent at the margin may not be a healthy choice for the national economy.

In the transportation business, the value of time is almost invariably included in the list of costs and benefits. This raises a number of issues. A new rule that saves travel time adds to the consumer surplus of those who traveled before the change and will induce additional travel. These effects are very important benefits of the rule. On a traditional price/quantity demand curve, time savings are normally regarded as a shift in the demand curve. The result can range from passengers' willingness to pay more for the faster flight, keeping the volume the same, to more travel taking place at the same price. There is no way to measure the benefits without starting with a demand curve. The reliability of estimates of the shape of the curve falls off as one departs from observed experience. Extrapolating into new regions is hazardous—although economists must often do that. It may be practical to look somewhat more grossly at willingness to pay without considering the new consumer surplus generated. This is not necessarily the best approach, but it may serve the purpose and provide a conservative estimate of the benefits.

Analysis of Benefits

In the approach to measurement of economic impacts, most (if not all) economists would prefer to use revealed preference. Where there is observed experience in the relevant range of the impacts, new models can be designed for the functions of interest, but in many cases traditional models are fine.

In some cases, economists may have observations of a revealed preference but not of the underlying causal variables. In these cases some kind of hedonic model may be the method of choice. In many cases there may be no direct experience at all and some other technique must be used to obtain measures of the effects. There has been some substantial development of techniques for measurement in these circumstances. Some of the techniques appear to provide reasonable results; others are more suspect. These techniques are not always sure, but they may be all we have.

There will always be some impacts that cannot be measured. Once the measurable impacts have been dealt with, analysts can conjecture what the impacts from the unmeasurable would have to be to result in an acceptable project. While this is fine for a single action, it is less helpful when comparing sets of actions.

The suggestion by Mr. Beshers that small effects can be excluded may not wise. Many of the effects observed at the individual level add up substantially when the entire population is considered. The changes considered are mainly at the margin, where the individual impact is small, even microscopic. However, it is the aggregate that is of interest, and this could be considerable. The chief concern is benefits or costs that cannot be measured. Often researchers base their conclusions on what they can measure and ignore the rest. It may well be that what is left out is much more important than what is included. This trap should be avoided.

Point Estimates, Accounting for Likelihood, Scenarios, and Ranges

Ultimately the use of benefit-cost analysis is to compare alternative actions. It also provides a justification for an action by itself. Any action without a positive net benefit would need to be justified on some other compelling basis. To make comparisons, point estimates are needed. Good point estimates of the net benefit should reflect the likelihood of the dispersion of the events that might occur.

For purposes of expressing confidence in the estimate, some additional information might be useful. One could create a set of scenarios that would span the range of possible outcomes and compute the net benefits under each scenario. This would give a sense of the robustness of the estimates and could be very helpful. If what is thought to be the worst case scenario, for example, still yields positive net benefits, one can be reasonably confident the action is worthwhile.

Public Confidence Issue

The issue of the benefit of improving public confidence is very interesting. At first glance it may appear that, for practical purposes, user confidence is reflected in the demand for air service. One could, in theory, determine for any time following an accident whether a reduction in expected travel occurred. This is difficult because of the many other confounding factors, but it may be worthwhile to see if such an effect can be identified.

The situation is different for nonusers. They could be severely traumatized by an aviation accident resulting in a loss of productivity in their work and possibly other dysfunction. Of course, even users who continue to fly may be so frightened that they, too, lose productivity. The anniversary of the Oklahoma City bombing is a case in point. Several government workers interviewed on TV expressed fear to go to work on that day fearing a repeat event on the anniversary. Those expressing those feelings were probably uncomfortable all that day and their productivity may have suffered , not only on that day but probably on many others.

Such costs could be enormous. Attributing large cost savings or benefits to every safety improvement could justify nearly any improvement and introduce a substantial bias in favor of any and all safety-related actions. There are many events unrelated to FAA rulemaking that may have similar effects. It is uncertain how they should be handled in a pragmatic BCA. Alternative ways to counter the phenomenon should be explored.

It may be more appropriate, for example, to assume that in such cases some kind of therapy could be applied to ameliorate the trauma. This would have a cost, but it would hopefully avoid the large cost of the effect.

There are many traumatizing events in our lives that are simply part of living, and we cannot begin to attribute their impacts. It might be best simply to ignore them. Alternatively, they can be treated qualitatively and left out of quantitative measurements. The pros and cons of the quantitative analysis should be considered.

Dislocation and Disruption

Anytime there is a change in the rules, it is likely that some segments will benefit and others lose. The controversy over requiring general aviation aircraft to be equipped with transponders may be instructive. The old guys with their vintage planes who fly only on weekends reacted strongly against having to put a piece of expensive equipment in their planes. No doubt some of them could not afford the equipment and would rather have used what little money they had to maintain their aircraft and buy fuel. The new regulations might make past investments obsolete or seriously affect their value.

One can certainly imagine actions that will have enormous net benefits yet also have very high costs—costs unaffordable by certain of the affected segments. Care must be taken not to ignore the impact of such actions. The inability of some segment of the population to take advantage of benefits reduces the aggregate benefit and may cause great disruption in their use of airspace and ground facilities.