Benefit-Cost Analysis: Practitioners Guidance for NOAA's Programs

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Acronyms

BCA	Benefit-Cost Analysis
BCR	Benefit-to-Cost Ratio
CET	NOAA Chief Economist team
DOE	Department of Energy
DOT	Department of Transportation
E.O.	Executive Order
EIA	Economic Impact Analysis
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
GDP	Gross Domestic Product
IRR	Internal Rate of Return
NAO	NOAA Administrative Order
NB	Net Benefit
NCHRP	National Cooperative Highway Research Program (within Transportation Research Board)
NOAA	National Oceanic and Atmospheric Administration
NPV	Net Present Value
OIRA	Office of Information and Regulatory Affairs (within OMB)
OMB	Office of Management and Budget

Glossary

Base-year	Represents a currency year selected for inflation adjustment (or for reporting all real monetary values)
Baseline	Refers to the scenario without the proposed policy action or project. Sometimes it is referred to as the “status quo” or the “initial no action scenario.”
Benefit-cost analysis (BCA)	A tool for evaluating and comparing the benefits and costs of a policy action or project to determine whether the expenditures generate sufficient benefits to targeted groups or society.
Benefit-to-cost ratio (BCR)	A ratio that helps prioritize spending across projects particularly when resources are limited. It is estimated by dividing the present value of benefits to the present value of costs. However, which benefits and costs to include in the calculation depends on the goal of BCA as the example in Appendix B-6 shows.
Discounting	Discounting is the process of converting future values of money to present (or current-year) value. In effect, discounting accounts for the time value of money. Simply put, discounting expresses how much future benefits and costs are worth today. Discounting requires using an appropriate real discount rate.
Distributional analysis (effect)	Shows how the benefits and costs of a selected policy action or project are distributed among various social groups (e.g., traditionally underserved or disadvantaged communities, low-income groups, and minorities).
Economic impact analysis (EIA)	A method of analyzing the overall economic impacts of a policy action or project on the regional or national economy. EIA captures all potential impacts attributable to a policy action or project using such aggregate measures as change in productivity, profitability, (un)employment, wages, government revenues or expenditures, trade balances, and real income or gross domestic product.
GDP Deflator	GDP implicit price deflator, or GDP deflator, measures changes in the prices of goods and services produced in the United States, including those exported to other countries. Prices of imports are excluded. It is estimated as the ratio of the current-dollar value of GDP to its corresponding base-year dollar value, multiplied by 100.
Internal rate of return (IRR)	A measure that helps identify financial investments with the highest monetary returns (compared to a given threshold). It is estimated by setting the NPV formula to zero and solving for the discount rate (a computationally challenging approach).
Net Benefit	A measure obtained when the sum of a stream of costs over time is subtracted from the sum of a stream of benefits over time. It shows

	the magnitude of welfare gains.
Net present value (NPV)	NPV is a net benefit discounted using an appropriate discount rate. That is, NPV is obtained by subtracting the present value of (discounted) costs from the present value of (discounted) benefits.
Real Discount Rate	OMB defines the risk-free discount rate as the average real (inflation-adjusted) rate of return on long-term U.S. government debt over the last 30 years.
Social benefits	The favorable effects society gains due to a policy change or regulatory action.
Social costs	The total burden on society due to a policy change or regulatory action.
Threshold or break-even analysis	Refer to the process of estimating the minimum value of the non-quantified benefits that would be sufficient to cover the non-quantified costs and yield zero net benefits.
Transfer payment	Refers to a shift in money (or other item of value) from one group to another without affecting total resources available to society or without producing any direct change in aggregate social welfare.

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Executive Summary

Background

Benefit-cost analysis (BCA) is one of the tools for conducting economic evaluations and examining project tradeoffs to support sound policy decisions. BCA is more generally defined as a measure of a project's societal value because it quantifies the project's societal effects and makes costs and benefits comparable in monetary terms. The Office of Management and Budget (OMB) Circular A-4 describes BCA as a primary analytical tool for conducting regulatory analysis. According to the Circular, when and if benefits and costs of regulatory alternatives are fully quantified and expressed in monetary values (including description of how the net benefits are distributed among different groups), BCA provides decision makers with a clear indication of the most efficient alternative that generates the largest net benefits or welfare improvement to society. However, when it becomes impossible to fully quantify and express some of the benefits or costs of the alternatives under consideration in monetary terms, the OMB Circular A-4 suggests to exercise professional judgment in determining the importance of such benefits or costs in the overall analysis, on the one hand, and/or conduct a "threshold" or "break-even" analysis to determine their significance, on the other.

A BCA is widely used for investment decisions by both private and public entities. Unlike private firms that focus mainly on their own costs and benefits, decisions by government entities take into account the social benefits and costs to evaluate the overall impacts of investment projects on society at large. Due to the government's broad scope, the BCA being undertaken by government entities is often termed as Social Benefit-Cost Analysis. In addition, there are various statutory and regulatory requirements as well as circulars from the OMB that direct Federal agencies to conduct a BCA to justify the implementation of their regulatory actions and other government investments. An assessment of benefits and costs is required for policy actions or projects that are deemed to be "significant".

This BCA guidance is prepared for general use in NOAA Line Offices and programs where BCA guidance does not exist. The guidance is not designed to serve a specific program or project. Rather, it provides the fundamentals of the BCA methods that can easily be adapted to the needs of various NOAA Line Offices and programs desiring to compare benefits and costs of their projects as part of their decision making process and budget justification. For instance, the guidance can be adapted to specific non-regulatory projects, such as investments in green infrastructure, or projects on nature-based solutions that can reduce the impacts of coastal hazards. In addition, some NOAA Line Offices may routinely need to conduct a BCA due to regulatory requirements. Overall, the guidance provides a summary of the methodological approaches and the steps required to conduct a BCA of programs, project expenditures and other large investments to the NOAA practitioners, including project leads and managers, economists, and contractors in various Line Offices, responsible for developing a BCA.

In addition to outlining the basic components essential to any BCA, the guidance includes links to multiple sources and other agencies' BCA guidances and applications. This would furnish NOAA BCA practitioners with relevant materials to modify or incorporate additional contents, as necessary, to fit the requirements of their specific projects using their professional judgment and in consultation with their project economists or the NOAA Chief Economist team (CET). The CET is available to provide support and advice to all Line Offices on developing economic analyses that align with their respective project or program needs.

Conducting BCA

This BCA guidance presents the legal requirements mandating BCA and the BCA framework that outlines its basic components.

Requirements mandating BCA

The following are the list of statutes and executive orders (E.O.s) as well as OMB Circulars that more specifically require conducting a BCA and are deemed potentially relevant to various NOAA programs.

- E.O. 12866: "Regulatory Planning and Review" - states the principal analytical requirements for assessing the costs and benefits for federal agencies' regulations. This E.O. was partly amended by E.O. 14094: "Modernizing Regulatory Review."
- E.O. 13563: "Improving Regulation and Regulatory Review" - requires employing the best available techniques to quantify anticipated present and future benefits and costs of alternative regulatory actions as accurately as possible, and choosing the action that maximizes net benefits. It also encourages to include qualitative descriptions for values difficult or impossible to quantify.
- E.O. 12893: "Principles for Federal Infrastructure Investments" - states the need for undertaking "Systematic Analysis of Expected Benefits and Costs" of infrastructure

investments and outlines the steps needed to be taken while conducting the analysis. Examples of infrastructure investments include direct spending and grants for transportation, water resources, energy, and environmental protection.

- The Unfunded Mandates Reform Act of 1995 (UMRA) - instructs agencies to conduct a BCA and distributional analysis, and provide estimates of macroeconomic impacts if the federal regulations result in an annual expenditure by State, local, and tribal governments, in the aggregate, or by the private sector, of $100 million or more (adjusted annually for inflation).
- The Evidence Act of 2018 - statutorily mandates evidence-building activities in the Federal government to improve access to data, employ the best possible information and analysis to decision making, and expand evaluation capacity. The revised OMB guidance issued in 2021 on the implementation of the Evidence Act recommends agencies to employ the full range of evidence types and methodological approaches (that potentially include conducting BCA) in the activities they plan to undertake.
- OMB Circular A-4: “Regulatory Analysis” - as the current OMB guidance on the implementation of E.O. 12866 of September 30, 1993, it serves for defining good regulatory analysis and standardizing the way benefits and costs of Federal regulatory actions are measured and reported. The Circular details key elements and steps necessary for conducting a regulatory impact analysis, including a qualitative and quantitative evaluation of benefits and costs of proposed and alternatives policy actions. The requirements in this Circular are the basis for the BCA framework discussed in this guidance.
- OMB Circular A-94: “Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs” - mainly provides a general guidance for conducting benefit-cost and cost-effectiveness analyses and a specific guidance on the discount rates to be used in evaluating Federal programs whose benefits and costs are distributed over time.

The general BCA framework

Regardless of the differences that may arise based on the type or complexity of the policy action or project to be evaluated, the following are the basic components of a BCA, depicting the step-by-step approach any practitioner should follow while conducting BCA.

BCA components	**Description**
1. Describe the statement of need for conducting BCA	Briefly articulate the need for the proposed policy action or the problem the project is trying to solve, including the legal requirements mandating undertaking BCA.
2. Identify alternative policy changes or projects	Instead of focusing on a single policy action or project, identify and assess potential alternative policies or projects to ensure that other more cost-beneficial options are not left out from consideration.
3. Identify baseline conditions	Establish a baseline and specify the conditions that would serve as references for evaluating the expected costs and benefits of the alternative policy actions or projects under consideration. The baseline is also considered as the *status quo* or the *no action alternative*.
4. Determine appropriate analysis period	Select an appropriate analysis period that helps capture the comprehensive benefits and costs that flow over the life cycle of the policy action or project.
5. Predict policy or project outcomes	For each potential alternative policy or project identified for analysis, clearly outline the causal pathway that links the change in policy or project to the corresponding potential outcomes. This involves identifying the *direct* and *indirect potential* impacts (outcomes) together with the appropriate quantitative or qualitative measures that capture these impacts, estimating and comparing the expected impacts under the baseline and after the policy change or implementation of the project, and finally quantitatively and/or qualitatively describing the results obtained.
6. Estimate benefits and costs	Categorize the potential impacts identified, predicated and described above into benefits and costs and express them in monetary terms. Use your professional judgment while categorizing benefits and costs based on the goals of the policy action or project under consideration. More generally, benefits represent the potential impacts (or outcomes) identified as the direct or indirect outputs or consequences, and costs denote the potential impacts (or outcomes) identified as measures of the inputs or resources needed to implement and operate the policy change or project and achieve the desired goals.

7. Discount future benefits and costs using appropriate discount rates	Discount the future monetary values of the streams of benefits and costs occurring over several years and express them in present value terms. By expressing all the monetary values in the same base year, discounting facilitates comparison between benefits and costs. Discounting requires using the appropriate discount rate and analysis period selected for the policy action or project under consideration.
8. Compare benefits and costs	Compare the present value of benefits and costs using any or all of the standardized summary measures commonly used in BCA: Net Benefits or Net Present Value (NPV), Benefit-to-Cost Ratio (BCR), and Internal Rate of Return (IRR). Which summary measure(s) to use depends primarily on the objective(s) of the policy action or project. The OMB Circular A-4 recommends using NPV when selecting an alternative that maximizes net benefits, and IRR when the primary focus is identifying financial investments with the highest monetary returns. The Circular advises not to use BCR alone as this measure is not a meaningful indicator of net benefits and is likely to yield misleading results.
9. Analyze risks and uncertainties	Identify the sources of risks and uncertainties and employ measures that minimize their impacts on the BCA results, such as using better data and prediction models. When feasible, conduct sensitivity analysis to show decision makers how uncertainties impact the BCA results. Accept and present the risks and uncertainties when they are not avoidable to improve the basis for decision making.
10. Conduct distributional analysis	Conduct distributional analysis to show how the benefits and costs of the selected policy action or project are distributed among various social groups; e.g., traditionally underserved or disadvantaged communities, low-income groups, and minorities.

Benefit-Cost Analysis: Practitioners Guidance for NOAA's Programs

1. Introduction and Background

1.1 Why Benefit-Cost Analysis in NOAA?

Government agencies implement various policy actions or undertake projects to provide a wide range of products and services to the general public and business entities in their jurisdiction. To ensure that public finance and resources are efficiently utilized in endeavors that maximize social benefits (i.e., benefits to society as a whole), agencies need to evaluate the benefits and costs of the policy actions or projects they plan to undertake. Benefit-cost analysis (BCA) is the primary analytical tool for conducting economic evaluations and examining project tradeoffs to support sound policy decisions. As such, there are various statutory and regulatory requirements as well as circulars from the Office of Management and Budget (OMB) that direct Federal agencies to conduct a BCA to justify the implementation of their regulatory actions and other government investments. As explained below, while these analytical requirements in general encourage conducting a BCA for all policy actions or projects, they in particular mandate conducting BCA for policy actions or projects that are deemed to be "significant".[1]

This guidance is prepared for general use in NOAA Line Offices and programs where BCA guidance does not exist. The guidance is not designed to serve a specific program or project. Rather, it provides the fundamentals of the BCA methods that can be easily adapted to the needs of various NOAA Line Offices and programs desiring to compare benefits and costs of their projects as part of their decision making process and budget justification. For instance, the guidance can be adapted to specific non-regulatory projects, such as investments in green infrastructure, or projects on nature-based solutions that can reduce impacts of coastal hazards.[2] On the other hand, some NOAA Line Offices may routinely need to conduct a BCA due to regulatory requirements. The purpose of this guidance is therefore to provide a summary of the methodological approaches and the steps required to conduct a BCA to NOAA practitioners, including project leads and managers, economists,

[1] See E.O. 12866 (1993, Sec. 3(f) (as amended by Executive Order 14094 E.O. 14094 (2023)) for the definition and explanation of a "significant regulatory action."
[2] For more details see the Office for Coastal Management, Digital Coast website - https://coast.noaa.gov/digitalcoast/training/green.html

and contractors in various Line Offices, responsible for developing a BCA. The guidance also provides links to materials that will be useful to practitioners in NOAA Line Offices when conducting BCA. Practitioners in NOAA are encouraged to familiarize themselves with this guidance and relevant statutory and regulatory documents while conducting a BCA.

It should be noted that ensuring the availability of funds for conducting a BCA should be an integral part of the planning process. As a result, NOAA large-scale programs planning to conduct a BCA should include adequate funding for BCAs in their annual budget requests. Some of that budget may be needed to compile data for the BCA that would not otherwise be available. Programs should check to see if relevant data is available from existing sources before undertaking new data collections. The latter may require Paperwork Reduction Act approval.

1.2 What is BCA?

A BCA is more generally defined as a measure of "a project's societal value by quantifying the project's societal effects and making costs and benefits comparable in monetary terms."[3] The OMB Circular A-4 also describes BCA as the primary analytical tool for conducting regulatory analysis. It states that, when and if the benefits and costs of regulatory alternatives are fully quantified and expressed in monetary values (ignoring distributional impacts), BCA can provide decision makers with a clear indication of the most efficient alternative, among the alternatives analyzed, that generates the largest net benefits to society.[4] However, when it becomes impossible to quantify and express in monetary terms some of the important benefits and costs of the alternatives under consideration, the one with the largest net benefit (in monetary terms) will not necessarily be the most efficient alternative. In such a case, the OMB Circular A-4 suggests to "exercise professional judgment in identifying the importance of non-quantified factors and assess as best you can how they might change the ranking of alternatives based on estimated net benefits."[5] In addition, where the non-quantified benefits and costs turn out to be important, Circular A-4 recommends conducting a "threshold" or "break-even" analysis to determine their significance.[6]

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[3] See Koopmans & Mouter (2020, p. 1). More details on "social evaluation" and its theoretical foundation can be found in Rothenberg, J. (1969, pp.1-7).
[4] See OMB Circular A-4 (2003, p. 2). Taking the distributional effects into consideration helps assess how the net benefits are distributed among different groups.
[5] See OMB Circular A-4 (2003, p. 10).
[6] According to OMB Circular A-4 (2003, p. 2), conducting a threshold or break-even analysis helps the sponsor of a BCA estimate the minimum value of the non-quantified benefits sufficient to cover the non-quantified costs and yield zero net benefits. For examples on the application of this method of analysis in environmental,

A BCA is widely used for investment decisions by both private and public entities. Unlike private firms that focus mainly on their own costs and benefits, decisions by government entities take into account the social benefits and costs[7] to evaluate the overall impacts of investment projects on society at large.[8] Due to the government's broad scope, the BCA being undertaken by government entities is often termed as Social Benefit-Cost Analysis.[9]

1.3 BCA vs. Economic Impact Analysis

It is important to note that BCA is different from other types of economic analysis[10] in general and economic impact analysis (EIA) in particular. This section focuses on showing the difference between BCA and EIA. The comparison is based on these two types of analyses mainly because (1) both are widely used analytical approaches, and (2) BCA is most often confused with EIA.

As discussed above, BCA is the primary tool used in decision making that provides a useful benchmark for evaluating and comparing the potential benefits and costs accruing to the individuals or entities impacted by a policy action or project under consideration.[11] That is, by identifying the incremental benefits and costs accruing to the impacted groups, BCA helps decision makers determine whether a policy action or project will generate a positive net benefit, where the incremental benefits exceed the incremental costs. As a result, BCA is the tool primarily used to justify whether the expenditures resulting from a proposed policy action or project generate sufficient benefits to all affected groups or society.[12]

In contrast, EIA is used to identify and analyze all potential impacts on the regional or national economy attributable to a policy action or project using such aggregate measures as change in

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natural resource and cultural heritage studies, see St-Hilaire et al. (2016), Sathiadhas et al. (2009) and Calabro (2017).

[7] Generally, social benefit is defined as the favorable effects society gains due to a policy or action, while social cost is envisaged as the total burden on society due to a policy or action. The various agencies' BCA documents cited in this guidance use more specific definitions related to their respective programs and projects.

[8] For example, FHWA (2012), FRA (2016), U.S. DOT (2022), and U.S. Army (2018) use BCA to justify their respective programs, projects or infrastructure investments.

[9] See Koopmans & Mouter (2020, p. 2)

[10] A few examples of other types of economic analysis include: Cost-effectiveness analysis (CEA), equity assessment, and cost-utility analysis (CUA).

[11] According to Rothenberg, J. (1969, p. 38), BCA always refers to "the population for whom changes in well-being are deemed relevant by the appropriate policy-maker."

[12] See U.S. EPA (2010, p.1-4) that extends the analysis to all affected groups in contrast to the OMB Circular A-4, which restricts analysis to only targeted groups.

productivity, profitability, (un)employment, wages, government revenues or expenditures, trade balances, and real income or gross domestic product (GDP). Unlike in EIA, some effects, such as the second and third order impacts (e.g., jobs and sales) generated from the first order benefits, are considered transfers in BCA and are not reflected in the net benefit calculation to avoid double counting. EIA attributes all of these economic impacts (i.e., the direct, indirect and induced impacts) of a policy action or project, while BCA focuses on the incremental net benefit resulting from the policy action or project on all affected populations or entities. As a result, a project with a negative net benefit in BCA from a national standpoint could generate positive regional economic impacts in EIA. For example, an investment that resulted in an overall negative net benefit could vitalize economic activities within a specific region by creating more jobs and generating income.[13] In this scenario where the societal net benefit is negative, transfers that benefit one region represent losses to other regions.

[13] The following provide more discussions and examples on or differences between BCA and EIA: FHWA (2012, p. 14); Koopmans & Mouter (2020, pp.6-7); U.S. EPA (2010, p. 9-2); U.S. DOT (2022, pp.30-31); FRA (2016, pp. 9-10); Turner, et al. (2021, pp.2-3); and Weisbrod, et al. (2016, section 3) .

Text Box 1. Distinctions between BCA and EIA

Given a policy action or project:

- BCA is based on the theoretical foundation of welfare economics (which investigates the social desirability of alternative economic situations). EIA is primarily based on economic models that analyze the interdependence and causal relationship between different sectors of the economy, such as input-output and regional economic models.
- BCA evaluates the overall worthiness of a policy or project in a specific area, but EIA assesses the economic effects of a project or policy on a specific region or community.
- BCA captures welfare changes on society, but EIA examines the overall impact on the economy in a specific area.
- BCA primarily focuses on total social benefits and total social costs with respect to impacted groups, while EIA focuses on the components and distribution of the total social benefits and costs.
- BCA compares a single total benefit metric against a single total cost metric. But EIA provides insight into the mix or distribution of impacts over time, over space and over various impact elements (types of effects and types of affected parties). BCA results are reported in metrics such as Net Present Value (NPV), Benefit-Cost Ratio (BCR), and Internal Rate of Return (IRR). EIA results are reported using such aggregate measures as change in productivity, job creation, wages, government revenues or expenditures, trade balances, and income generation.
- Unlike BCA, EIA does not examine how resources might have been put to alternative beneficial uses, rather it assesses the impacts of the resources in increasing economic activity within a region.
- BCA produces a summary measure (i.e., net benefits) based on estimates of social benefits and costs, but EIA generates a range of estimates that capture the private benefits and costs associated with affected entities (e.g., real income or real GDP, (un)employment, government revenues or expenditures, and trade balance).
- In BCA, transfers of economic welfare from one group to another are assumed to cancel each other out (because the effects reported as cost by one group become benefits to the other group). This is not the case in EIA because individuals within a target group (e.g., taxpayers, consumers, producers, government entities, and other sub-groups) are all considered separately.
- Overall, there is a greater need for disaggregation in EIA than in BCA, resulting in a need to present EIA results for specific counties or other geographic units or types of entities, as appropriate. As a result, EIA requires developing complex estimation models.

Note: Summarized from FHWA (2012, p. 14), Koopmans & Mouter (2020, pp.3, 6-7), U.S. EPA (2010, p. 9-2), U.S. DOT (2022, pp.30-31),and FRA (2016, pp. 9-10).

Text Box 1, Distinctions between BCA and EIA, describes what BCA is and is not, given a policy action or project.

1.4 How to Use this Guidance

The primary goal of this guidance is to provide a general “how to” approach for identifying and quantifying, where possible, the benefits and costs of planned policy actions or projects.

The guidance outlines the basic components essential to any BCA based on multiple sources (see references) and other agencies’ guidance and applications. Sponsors of BCA are encouraged to modify or incorporate additional contents, as necessary, to fit the requirements of their specific projects using their professional judgment and in consultation with the project economist or the NOAA Chief Economist team (CET).

1.5 How the Chief Economist Team can help NOAA Practitioners

The CET is available to provide support and advice to all Line Offices on developing economic analysis that aligns with the project or program needs. We highly recommend the Line Offices without economic analysis capacity to request CET support as described in the NOAA Administrative Order (NAO) 216-124, on Policy on Development and Coordination of Economic Analyses and Statistics for NOAA.[14] The NAO 216-124 specifies that NOAA Line Offices should consult with the Chief Economist during the design phase, and schedule follow up(s) as needed, for the following analysis: Regulatory Impact Analysis of significant rulemakings (as defined by E.O. 12866 and 13563), economic analysis developed for budget justification (e.g., economic impact analysis, BCA, return of investment analysis), economic analyses requested by the Department of Commerce, Congress, or the Executive Office of the President, and economic analysis developed to support performance measures and the Foundations for Evidence-Based Act of 2018, and any other significant studies, on a case-by-case basis as determined by NOAA leadership.

In addition, the CET developed a guide for Economic Valuation that presents a step-by-step approach to planning and executing economic research for investments in research and development.[15] The guide discusses methods for estimating the economic value of benefits, and contains a list of regulations that mandate economic analyses. Line Offices are encouraged to reach out to the CET with questions on applying the guide to the planning and execution of economic analyses.

2. Conducting Benefit-Cost Analysis

This section provides background information on BCA and outlines the BCA framework. The background information focuses on two major topics: the legal requirements mandating BCA and the need for scoping BCA. Under the BCA framework, the basic components of BCA are discussed in detail, depicting the step-by-step approach any practitioner should follow while conducting BCA.

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[14] See NAO 216-124
[15] See CET Guide for Economic Valuation (2021)

2.1 Statutory and Executive Order Requirements and OMB Circulars for Conducting BCA

There are a number of statutes and executive orders (E.O.s) that direct agencies to conduct different types of economic analyses. In this guidance, only the directives that more specifically require conducting a BCA and are deemed potentially relevant to various NOAA programs are listed with a brief description.[16]

(a) E.O. 12866: "Regulatory Planning and Review"

This E.O. provides the principal analytical requirements for assessing the costs and benefits for federal agencies' regulations in order to ensure that the benefits of a regulation justify the costs. While E.O. 12866 Section 1(b)(6) requires assessment of costs and benefits for all rules, Sections 6(a)(3)(B) and 6(a)(3)(C) specifically require conducting a more rigorous and detailed benefit-cost analysis for actions deemed "significant regulatory actions" by OMB's Office of Information and Regulatory Affairs (OIRA)."[17] Circular A-4 provides guidance on creating a formal BCA to satisfy the requirement in E.O. 12866 Section 6(a)(3)(C). In addition to conducting a detailed BCA for the significant regulatory action, the E.O. directs agencies to include a similar analysis of potentially effective and reasonably feasible alternatives. The E.O. also requires that a significant regulatory action be reviewed by OIRA before it is published in the Federal Register or otherwise issued to the public.

(b) E.O. 13563: "Improving Regulation and Regulatory Review"

This E.O. specifically requires agencies to "use the best available techniques to quantify anticipated present and future benefits and costs as accurately as possible." It also requires agencies to assess alternative regulatory actions and choose the action that "maximizes net benefits (including potential economic, environmental, public health and safety, and other advantages…" The E.O. encourages agencies to "consider (and discuss qualitatively) values that are difficult or impossible to quantify, including equity, human dignity, fairness, and distributive impacts."[18]

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[16] For more details on the range of statutes and E.O.s, refer to CRS (2022); U.S. EPA (2010, ch 2); U.S. DOT (2022, p.6).

[17] See E.O. 12866 (1993) Section 3(f)(1) (as amended by E.O. 14094 (2023)) for the definition of a significant regulatory action.

[18] See E.O. 13563 (2011)

(c) E.O. 12893: “Principles for Federal Infrastructure Investments”

This E.O. states the need for undertaking “Systematic Analysis of Expected Benefits and Costs” of infrastructure investments and outlines the steps need to be taken while conducting the analysis. The infrastructure investments referenced in this E.O. include “direct spending and grants for transportation, water resources, energy, and environmental protection.” Although the E.O. specifically requires including “both quantitative and qualitative” as well as “market and non-market” measures in the analysis, it emphasizes that the “benefits and costs should be quantified and monetized to the maximum extent practicable” and appropriately discounted over the full life cycle of each project.”[19]

(d) The Unfunded Mandates Reform Act of 1995 (UMRA)

Title II of UMRA requires agencies to analyze costs resulting from regulations imposing federal mandates “that may result in the expenditure by State, local, and tribal governments, in the aggregate, or by the private sector, of $100 million or more (adjusted annually for inflation) in any one year.”[20] In such instances, agencies are required, among others, to conduct a BCA and distributional analysis, and provide estimates of macroeconomic impacts.

(e) The Evidence Act of 2018

The “Foundations for Evidence-Based Policymaking Act of 2018” (the Evidence Act) statutorily mandates evidence-building activities in the Federal government to improve access to data, employ the best possible information and analysis to decision making, and expand evaluation capacity.[21] The revised OMB guidance issued in 2021 on the implementation of the Evidence Act recommends agencies to employ “the full range of evidence types and methodological approaches” in the activities they plan to undertake.[22] Accordingly, the OMB guidance describes four broad types of evidence agencies should plan to collect: “foundational fact finding, policy analysis, program evaluation, and performance measurement.” The range of methodologies the OMB guidance suggested for agencies consideration include, but not limited to, “pilot projects, randomized controlled trials, quantitative survey research and statistical analysis, qualitative research, ethnography, research based on data linkages in which records from two or more datasets that refer to the same entity are joined, well established processes for community engagement and inclusion in research, and other approaches that may be informed by the social and behavioral sciences and

[19] See E.O. 12893 (1994)
[20] See UMRA (1995)
[21] See the Evidence Act (2018)
[22] See OMB Evidence Act Memorandum (2021, p. 10)

data science."[23] As an analytical approach primarily being used to analyze the benefits and costs of Federal policy actions or projects, BCA would fall in the "other approaches" category listed in the OMB guidance.

(f) OIRA Guidance: Assessing Environmental and Ecosystem Services

The Office of Information and Regulatory Affairs (OIRA), in collaboration with the Office of Science and Technology Policy (OSTP), prepared "Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis" to help agencies fully account for benefits and costs associated with the environment.[24] The aim of this first-ever guidance, released in 2024, is to advance and strengthen accounting for ecosystem services when conducting BCA of regulations and government investments. In this guidance the term ecosystem services "encompasses all relevant contributions to human welfare from the environment or ecosystems." The guidance includes best practices to help understand the relevant trade offs or complementarities among different ecosystem services and shows the steps that should be followed to account for and analyze the associated benefits and costs. The guidance is intended to be fully consistent with OMB Circulars A-4 and A-94 and outlines how to apply the principles in these Circulars when conducting analyses that involve ecosystem services, together with the specific considerations for the treatment of ecosystem services. More generally, the guidance states that for all regulatory impact analysis or BCA of federal projects, programs, or policies that involve ecosystem services "the same steps can be followed as for other analyses consistent with Circulars A-4 and A-94."

(g) OMB Circulars

OMB has issued Circulars to expand on the requirements of various E.O.s and to provide guidance documents to federal agencies. Two of OMB's Circulars relevant to BCA are presented below.

(i) OMB Circular A-4: "Regulatory Analysis"

OMB designed this Circular for "defining good regulatory analysis" and "standardizing the way benefits and costs of Federal regulatory actions are measured and reported."[25] As such, Circular A-4 remains the current OMB guidance for agencies preparing analyses under E.O. 12866 of September 30, 1993. It details the key elements as well as steps necessary for the preparation of a regulatory impact analysis, including, among others, a qualitative and quantitative evaluation of benefits and costs of the proposed action and the main alternatives under consideration. In addition, the circular provides guidance on when varying analytical

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[23] See OMB Evidence Act Memorandum (2021, p. 10) and Memorandum on Restoring Trust (2021)
[24] See OIRA Guidance (2024)
[25] See OMB Circular A-4 (2003, p. 1)

approaches may be appropriate (e.g., when to use cost-benefit analysis vs. cost-effectiveness analysis).[26] It is worth mentioning here that Circular A-4 recommends using a real discount rate of 3 percent and 7 percent per year for all regulatory analyses covering a period of up to 30 years into the future. While the 3 percent discount rate denotes the "social rate of time preference," the 7 percent discount rate is "an estimate of the average before-tax rate of return to private capital in the U.S. economy."[27] Note that several of the steps described in Circular A-4 are discussed in more detail below under the General BCA Framework.

(ii) OMB Circular A-94: "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs"

The goal of the Circular is to provide "general guidance for conducting benefit-cost and cost-effectiveness analyses" and "specific guidance on the discount rates to be used in evaluating Federal programs whose benefits and costs are distributed over time."[28] With few exceptions listed in the document, the Circular A-94 guidelines "apply to any analysis used to support Government decisions to initiate, renew, or expand programs or projects which would result in a series of identifiable benefits or costs." More specifically, the Circular applies to: "(1) Benefit-cost or cost-effectiveness analysis of Federal programs or policies, (2) regulatory impact analysis, (3) analysis of decisions whether to lease or purchase, and (4) asset valuation and sale analysis." The following cases that are governed by guidelines emanating from other relevant OMB Circulars or Federal government regulations are exempt, but Circular A-94 might be informative nonetheless: (1) Water resource projects, (2) Acquisition of commercial-type services by Government or contractor operation, and (3) Federal energy management programs.[29] Appendix C of this Circular provides discount rates for analyses of government programs listed above to which the Circular applies.[30] The Circular also provides suggestions on how to identify and address uncertainties and discusses the incidence and distributional effects of benefits and costs, along with discounted net benefits.

2.2 Configuring BCA to Local Conditions

The starting point of any BCA is defining or determining the geographic scope of the proposed policy action or project. This involves identifying the region(s) directly impacted by the proposed policy

[26] See OMB Circular A-4 (2003, pp. 2-12)
[27] See OMB Circular A-4 (2003, pp. 32-34). Note that Circular A-94 (1992) provides the discount rates that apply to BCA of all other government programs.
[28] See OMB Circular A-94 (1992, p. 3)
[29] See OMB Circular A-94 (1992, pp. 3-4).
[30] See OMB Circular A-94 Appendix C (2025, pp. 1-2). Note that OMB Circular A-94 Appendix D has been suspended since April 8, 2025.

action, which helps account for regional variations in benefits and/or costs and properly capture all the potential impacts. In some instances, there may be transfers of benefits or costs from one region to other regions that need to be properly accounted for. For instance, if the proposed policy action or project results in moving jobs in two regions, then the jobs gained in one may become losses in another.

Hence, it is often necessary to calibrate BCA to parameters representing the anticipated impacts in a specific region. This means that rather than using default parameters calibrated on national averages of observed benefits and/or costs (or those gathered from empirical studies), it is necessary to identify data and use parameters more individually customized to specific local or regional conditions as circumstances permit.[31]

2.3 General BCA Framework

BCA is an iterative process consisting of basic components that vary depending on the type and complexity of the project to be evaluated. BCA has wide application in government and private entities (for- or non-profit organizations) alike. Despite the differences in the scope and objectives of these entities, the basic BCA components in general remain the same. Subject to continuous reviews and revisions as additional information becomes available, the basic BCA components are presented below.[32]

2.3.1 Describe the statement of need for conducting BCA

Clearly stating the statement of need for conducting BCA is described as best practice by agencies undertaking various types of economic analyses.[33] In the context of regulatory analysis, OMB Circular A-4 suggests including a statement of the need for the proposed action.[34] In general, the statement of need should include the definition of the problem or policy goal to be addressed and the statutory, judicial or regulatory requirements that mandate undertaking BCA. Those conducting regulatory impact analysis should also describe the reasons for market failure or institutional failure to correct the problem and the justification of the need for federal action instead of other alternatives.[35] Examples of government interventions that help correct market failures and promote

[31] See FHWA (2012, p. 89)
[32] The following may provide more information: Robinson et al. (2019, ch 2); U.S. EPA Final Rule (2020); FAA (2020, ch 3); NASEM (2020, ch. 2).
[33] See, for example, U.S. EPA (2010, ch. 3); U.S. DOT (2022, p.7); NOAA OCM (2015, pp. 6-9)
[34] See OMB Circular A-4 (2003, p. 2)
[35] See U.S. EPA (2010, p. 3-2)

social welfare include: Setting emission standards to correct inefficiencies resulting from negative externalities (e.g. pollution from factories affecting nearby communities); and ensuring the provision of non-market goods or public goods (e.g., national defense or public parks). Government interventions are also often used to correct institutional failures and improve outcomes for society, examples include: NOAA developing strategies to explore both nature-based and engineered techniques to remove carbon from the atmosphere and marine system; NOAA providing better data and tools for local governments to manage disaster responses and recovery more effectively; the Federal Emergency Management Agency (FEMA) undertaking reforms to improve the inadequate disaster responses and coordination following Hurricane Katrina in 2005; and EPA introducing stricter environmental regulations and enforcement mechanisms to abate pollution and environmental degradation. For investment projects, carefully articulating "the problem that the investment is trying to solve and how the proposed improvement will help meet that objective"[36] is vital not only to properly frame the BCA but also to justify the impacts of the investment on users or society as a whole.

Text Box 2. Example - Statement of need for procurement of NOAA G550 aircraft

From 1980-2019, 45 tropical cyclones with losses exceeding $1-billion were responsible for 6,507 deaths and $956.3-billion in total damage, with an average of $21-billion per event (NOAA Billion-Dollar Weather and Climate Disasters). To save lives, mitigate property loss, and improve economic performance, the Nation requires the best hurricane watches, warnings, and forecasts, and analyses of hazardous tropical weather. To provide this information, and increase understanding of these hazards, NOAA's hurricane forecasters require extensive data sets including data on storm structure, pressure, humidity, winds, and temperature from high altitudes. This data is currently collected by a 23-year-old highly modified government-owned G-IV which is scheduled to be retired in 2024. To ensure the nation's hurricane forecasting capability does not degrade from its current status, NOAA will require another avenue by 2024 to collect this data. Critical, thorough analysis and a robust acquisition process per the Federal Acquisition Regulations (FAR) that considered all lease and buy options was conducted and found that the most economical, scientifically sound, and reliable way to continue providing this data is through the acquisition of a modified Gulfstream 550 aircraft (G550).

Text Box 2 provides an example of a statement of needs for procuring a NOAA G550 aircraft.

2.3.2 Identify alternative policy changes or projects

Rather than solely focusing on a single policy or project to address the problem(s) identified, assessing potential alternative policies or projects helps ensure other more cost-beneficial options

[36] See U.S. DOT (2022, p.7)

have not been ignored.[37] In this regard, the basic question any sponsor of a BCA should raise is whether there are other viable alternative policies or projects that can resolve the problem(s) under consideration. Potentially, this involves assessing what the likely outcomes would be “if no action were taken at all” or “if a different approach were implemented.”

The OMB Circular A-4 emphasizes the need to identify a manageable number of alternative regulatory approaches and conduct BCA to evaluate their respective likely outcomes. The Circular also provides a list of alternative regulatory actions that need to be considered when conducting a BCA.[38]

[37] See Robinson, et. al. (2019, p. 13)
[38] See OMB Circular A-4 (2003, pp.7-10) for more details.

Text Box 3. Identifying alternatives

Example 1. BCA of G550 Procurement
NOAA conducted a BCA to assess the feasibility of acquiring the G550 aircraft. The analysis identified and compared six potential alternatives to purchasing a new G550 aircraft: leasing a private/commercial G-IV aircraft, leasing a private/commercial G550 aircraft, continuing use of the current G-IV, using other government assets, using uncrewed systems, and using a NOAA-owned and -operated aircrafts to fulfill the nation's high-altitude hurricane data requirements. This analysis used the best data available and considered costs, scientific requirements, reliability, availability, and safety.

Example 2. Energy Conservation Standards
Department of Energy (DOE), in its 2020 final rule (1447 FR, Vol. 85, No. 7), adopted new technologically feasible and economically justified energy conservation standards for uninterruptible power supplies (UPSs), a class of battery chargers. DOE identified five potentially effective and reasonably feasible non-regulatory alternatives to the planned regulation and assessed their benefits and costs. These are: No new regulatory action; consumer rebates; consumer tax credits; manufacturer tax credits; voluntary energy efficiency targets; and bulk government purchases. These alternatives were analyzed whether they could possibly provide incentives for the same energy efficiency levels envisaged by the proposed rule. This is done by analyzing the effect of each alternative on the purchase of equipment that meets the efficiency levels corresponding to each trial standard level (TSL) adopted for the rulemaking.

Example 3. Charter Halibut Recreational Quota Entity (RQE) Funding
The National Marine Fisheries Service (NMFS), Alaska Region, conducted a regulatory review to examine the impact of a proposed fee collection program that would apply exclusively to the guided (i.e., chater) recreational Pacific halibut fishing sector in International Pacific Halibut Commision Regulatory Areas: Southeast Alaska and Southcentral Alaska (see "Regulatory Impact Review for a Proposed Regulatory Amendment: Charter Halibut Recreational Quota Entity Funding," October 2024; Regulations.gov Document ID: NOAA-NMFS-2024-0099-0002). NMFS conducted the impact analysis using two alternatives: the "no action" and "establishing a federal fee collection program." Under the second alternative, NMFS explored two fee collection mechanisms: "charter halibut stamp" and "annual operator fee." The latter fee option was further subdivided into two fee structures: "uniform fee" and "scaled to charter business activity." NMFS explored the benefits and challenges (i.e., the additional cost and resource needs) associated with administrative, data management, and enforcement of these fee collection mechanisms.

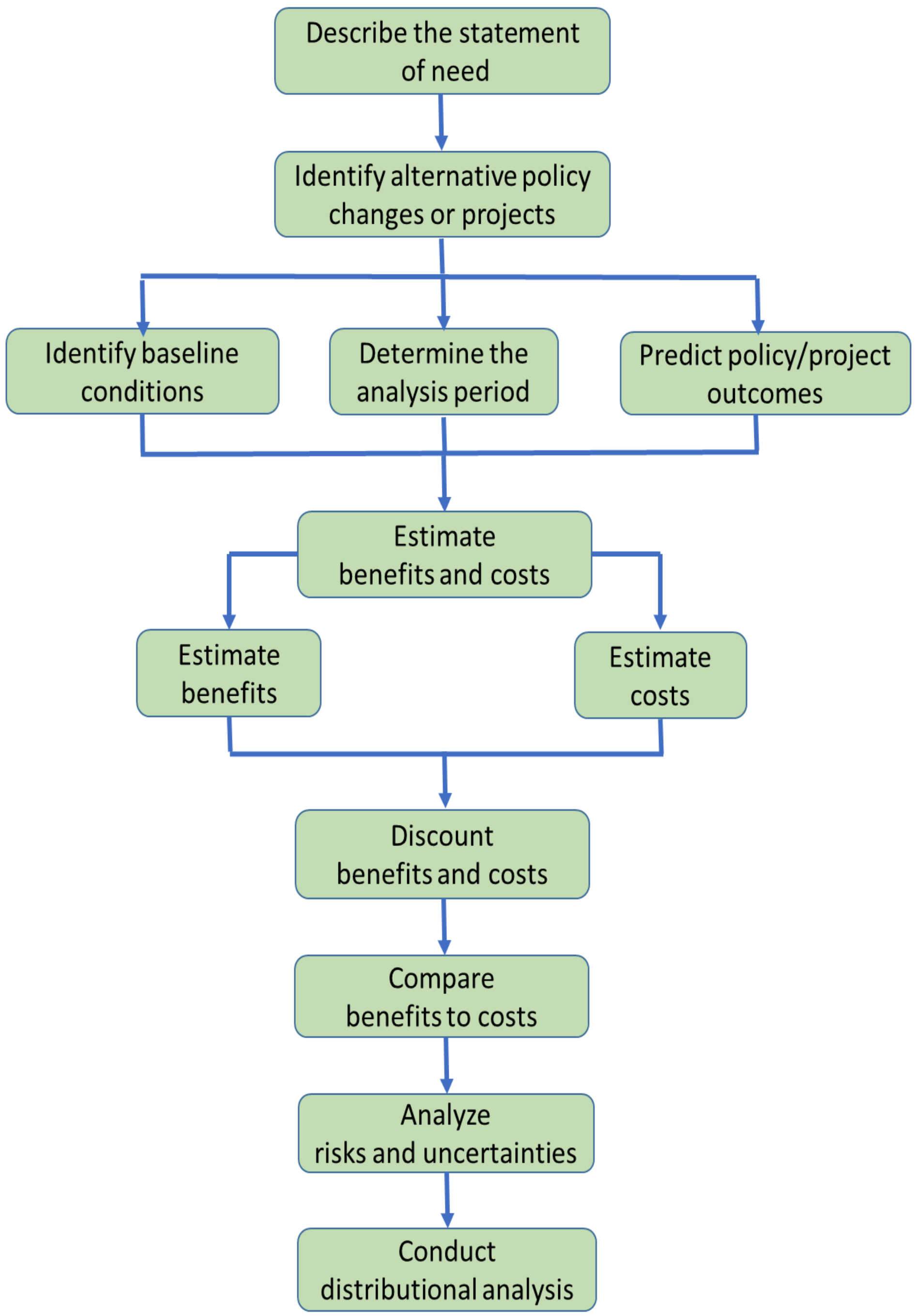
Text Box 3 provides three alternative examples: a BCA of G550 procurement, Energy Conservation Standards, and Charter Halibut Recreational Quota Entity (RQE) funding.

From an investment standpoint, FAA's BCA Guidance states that it is impossible to "identify an optimal course of action" unless the full range of economically viable alternatives is identified and evaluated.[39] The FAA Guidance also discusses in detail how economically viable investment alternatives can be identified using an airport expansion project as an example. However, identifying the full range of economically viable alternatives may not be feasible for most NOAA investments in environmental projects. NOAA BCA practitioners should use their professional judgment in identifying a list of economically viable investment alternatives based on the goal of their projects.

Comparing the size of the net benefits of alternatives under consideration indicates whether one policy option is more efficient than another from a resource use perspective. Then the alternative that yields the largest net benefits should be selected as the most efficient policy option to achieve the objective under consideration.

[39] See FAA (2020, Section 7)

Figure 1. BCA components, depicting the step-by-step approach



Adapted from Robinson et al. (2019, p. 12)

Figure 1 lists the Benefit Cost Analysis, depicting the step-by-step components beginning with the statement of need and progressing through conducting the distributional analysis. The image is adapted from Robinson et al. (2019, p. 12).

2.3.3 Identify baseline conditions

The baseline refers to the scenario without the proposed policy action or project, and is sometimes referred to as the "status quo" or the "no action scenario." According to OMB Circular A-4, the "no action" baseline helps assess what the world will be like if the proposed policy action or project is not adopted.[40] But "no action" or "no change" in the current program does not necessarily mean changes in current conditions will not be taking place at all. Actually, there will be changes in current conditions even in the absence of proposed action due to changes in underlying conditions not directly related to the proposed action (e.g., demographic changes, advance in technology, changes in economic activities, and climate change).[41] Based on the type of policy action or project under consideration, the "no action" baseline assessment can be framed in two different ways. (a) For cases where, absent the proposed policy action, there will be "no change" in the current government program, the current benefit or cost structure, can be assumed to remain unchanged. In such cases, the expected benefits and costs of the proposed policy action or project should be measured against the "constant" baseline benefits and costs, respectively. (b) For cases where it becomes reasonable to assume the world absent the proposed action will resemble the present, the baseline should reflect "the future effect of current government programs and policies."[42] This requires estimating the benefits and costs of the current government programs and policies over the period of analysis and comparing them against the expected benefits and costs of the proposed policy action or project.

Properly defining and specifying the baseline, using either of the above approaches as necessary, helps the sponsor of a BCA identify the stakeholders and beneficiaries and assess their conditions prior to the policy action or implementation of the project.[43] As such, a well-established baseline serves as a reference point for quantitatively evaluating the expected costs and benefits of the proposed policy action or project and its alternatives. The goal of any BCA is, therefore, comparing the state of the world without and with the proposed policy action or project, i.e., the "baseline

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[40] See OMB Circular A-4, (2003, p. 15)
[41] See U.S. EPA (2010, p. 5-1) and OMB Circular A-4, (2003, p. 15)
[42] See OMB Circular A-4 (2003, pp.15-16)
[43] U.S. EPA (2010, p.1.3): The first methodological question in BCA is: "who has "standing?" The most inclusive answer allows all persons who may be affected by the policy to have standing, regardless of where (or when) they live." But the OMB Circular A-4 (2003, p. 15) limits the scope of analysis to citizens and residents of the U.S. For impacts extending beyond the U.S. borders, OMB suggests the effects to be reported separately.

scenario" vs. the "policy scenario."[44] This shows that the accuracy of any BCA primarily depends on the correct specification of a baseline.

Text Box 4. Baseline specifications

Example 1: BCA of G550 procurement
For this project, NOAA started incurring costs in FY21, but profits don't accrue until after FY24. Hence, FY20 is used as the baseline in this analysis. (Note: The costs incurred prior to FY21 were assumed sunk costs for the purpose of this analysis, because OMB requested a BCA to justify the additional funding required to complete the G550 procurement process.)

Example 2: Projected benefits and costs of the Digital Coast
The Digital Coast is a NOAA website developed by the Office of Coastal Management (OCM) to meet the unique needs of the coastal management community by making it easier to locate and apply the resources needed to address coastal challenges. The website provides data, as well as the tools, training, and information needed to make this data truly useful.

Investments in the Digital Coast began in FY07, but benefits did not begin to accrue until FY09. OCM conducted its third follow-up BCA in 2015 covering an analysis period extending to FY33. Although not specifically stated, the BCA used the period prior to FY07 as a baseline. For more details, see NOAA OCM (2015).

Text Box 4, Baseline specifications, provides two examples: BCA of G550 procurement, and the projected benefits and costs of the Digital Coast.

The baseline specification varies based on the *type and objective of the policy action or project*, the *sponsor office or division's service area* (e.g., weather, climate, ocean and coasts, fisheries, satellites, marine aviation), and on a number of other factors, such as the *entities analyzed* (e.g., facilities, industries, sectors of the economy), *geographic location and resolution* (e.g., census blocks, GIS grid cells, counties, states, regions), and *years covered*. The U.S. EPA (2010) Guideline provides a detailed discussion of the guiding principles sponsors of BCA should follow.[45]

2.3.4 Determine appropriate analysis period

To accurately assess the net benefit of a policy action or project, it is essential to account for all benefits and costs over an appropriate time frame or period of analysis. Some investment projects, for instance, may typically require incurring large initial capital expenditures at an early stage of the projects, but the benefits from the investments may start accruing at a later stage and extend over several years. Hence, a sponsor of BCA should select an appropriate analysis period that helps capture the comprehensive benefits and costs that flow over the life cycle of the policy action or

[44] See U.S. EPA (2010, p. 5-1)
[45] See U.S. EPA (2010, pp. 5-2 - 5.6)

project. Depending on their expected useful service life, some projects may have a short analysis period (e.g., 3 or 5 years), while other projects may require a longer time horizon (e.g., 10, 20 or 30 years) to fully capture the associated benefits and costs.[46] As discussed above, this requires measuring the benefits and costs of a proposed policy action or project over the analysis period against a properly established baseline.

2.3.5 Predict policy or project outcomes

After identifying the potential alternative policy changes or projects to the proposed policy action or project as described above, it becomes necessary to clearly outline the causal pathway that links each policy change or project to the potential outcomes.[47] Here, the goal is to predict the potential impacts (or outcomes) for each policy change or project as realistically as possible and evaluate them both quantitatively and qualitatively in comparison to the baseline conditions.[48]

The following steps outline the process:

(1) Identify the direct impacts (or outcomes) of each policy change or project under consideration;
i.e., list all potential impacts on the affected individuals and/or entities

(2) Identify the expected indirect impacts (or outcomes) (i.e., both desirable and undesirable side-effects and ancillary consequences) of each policy change or project;

(3) Identify quantitative or qualitative measures, as necessary, that realistically capture the direct and indirect policy impacts (or outcomes);[49]

(4) Estimate the expected direct and indirect impacts (or outcomes) (a) under the baseline conditions and (b) due to the policy change or project;
e.g., expected number of affected individuals and/or entities each year, changes in their corresponding characteristics, and changes in other related factors.

(5) Compare the estimated impacts (or outcomes) under the baseline conditions with those resulting from the policy change or project;
Note: Ensure that changes likely to occur under the baseline (without any policy change or project) are not inappropriately attributed to a policy change or project.

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[46] For more discussions on the determination of the analysis period, see for example, U.S. DOT (2022, pp. 10-11); FAA (2020, p.8); U.S. EPA (2010, pp. 6-5 - 6-6); FRA (2016, pp. 9-10)

[47] Note that in henceforth discussion we consider the proposed policy action or project as part of the alternative policy actions or projects. The standard procedure is to apply BCA to the proposed as well as alternative policy actions or Projects and select the policy action or project that maximizes net benefits.

[48] More details are available at: Robinson, et al. (2019, p. 14); OMB Circular A-4 (pp. 2-3)

[49] Qualitative measures are used to describe non-quantifiable impacts (or outcomes).

(6) Describe quantitatively and/or qualitatively the results obtained.

Figure 2. Steps to predict policy outcomes

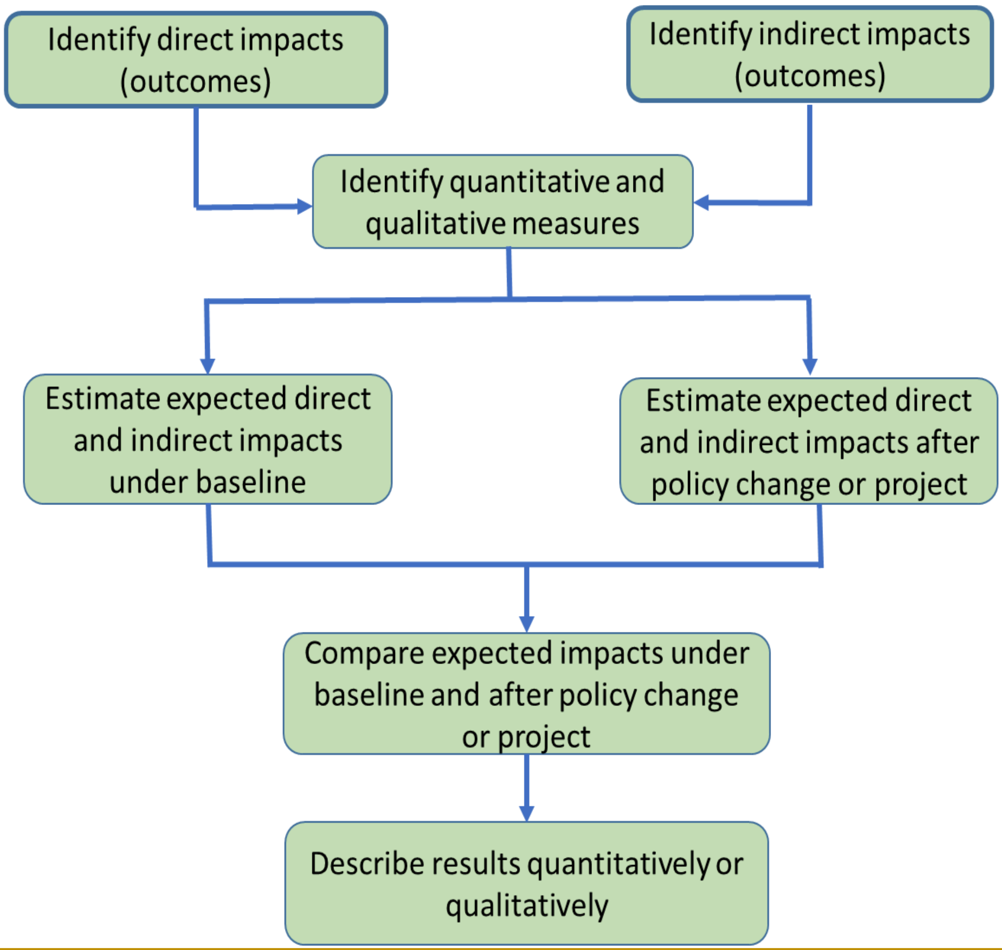

Figure 2 lists the steps to predict policy outcomes from identifying direct and indirect impacts to describing quantitative or qualitative results.

Note that the focus in this subsection is on identifying, predicting and describing the potential impacts (or outcomes) resulting (directly or indirectly) from the policy changes or projects under consideration. Categorizing these potential impacts into benefits and costs and expressing them in monetary terms will be the focus of subsequent subsections.

Text Box 5. Examples of direct and indirect benefits and costs

Human capital formation are benefits that people receive from education and training. For example, participants in Sea Grant training courses in aquaculture and improving fishing operations can apply new knowledge to modernize their businesses, which can result in efficiency gains.

Cultural values are non-market, indirect benefits from the environment that include aesthetic inspiration and cultural identity. An example of NOAA's contribution to cultural values are inventories of underwater cultural resources (such as battlefield sites) conducted by OAR's Office of Ocean Exploration to inform site management and preservation.

Non-use values are benefits that are reflected by people's willingness to pay for knowing that something exists. Non-use values have two components: the value of existence per se (existence value), and the potential benefits that something might bring in the future (quasi-option value). Some NOAA's marine sanctuaries have non-use value; this non-market, indirect benefit is reflected in some people's willingness to pay for the conservation of the sanctuaries, for example by giving donations to support management, even if they do not otherwise enjoy them. Note that there are marine sanctuaries that have use value as they allow for some recreational and commercial fishing, for example.

For climate hazard mitigation and resilience projects, avoided damages and losses constitute direct benefits, which in most cases are difficult to estimate. In contrast, identifying and estimating the costs for such projects is relatively easy because the outlays associated with undertaking the projects (i.e., constructing barriers or adopting a new technology to protect against hazards, mitigate their impacts, or enhance resilience) are readily available direct costs of the projects. On the other hand, delays or extra travel time resulting due to, for example, road closures while undertaking the project can be envisaged as indirect costs.

Text Box 5 provides examples of direct and indirect benefits and costs.

2.3.6 Estimate benefits and costs

Appropriately categorizing the potential impacts (or outcomes) of the alternative policy changes or project options (identified in subsection 2.3.5) as benefits or costs is an important procedure that primarily determines the quality and precision of the BCA. However, categorizing potential impacts as a benefit or cost is not always a straightforward process (or there is no a clear-cut rule) and varies across BCAs. Aside from mislabeling, there may be instances where a portion of a benefit can be categorized as a cost, or vice versa. Some actions may generate cost savings (negative costs) and/or negative benefits that affect incremental cost and benefit calculations, respectively. Obviously, the best approach is to use your professional judgment to categorize the benefits and costs based on the goals set by the proposed policy action or project. In this regard, while the goals the policy action or project claims to achieve (and at times the associated negative consequences) constitute the benefits, all the financial outlays and physical resources directed towards achieving these goals are considered costs.

A related, but slightly different, rule-of-thumb approach is to categorize the potential impacts (or outcomes) as inputs and outputs.[50] Simply put, costs can be envisaged as inputs or resources required for the implementation of the policy change or project, and benefits as the corresponding consequences or outcomes. As a result, all the potential impacts related to inputs or resources needed to implement and operate the policy change or project (e.g., investments in hurricane forecasting technology or in land and other natural resources used for developing transportation facilities, and expenditures on labor and materials) can be categorized as costs. In contrast, those potential impacts associated with the outputs or consequences[51] of the policy change or project under consideration (e.g., changes in welfare of impacted individuals such as reduced risk of death due to improved hurricane forecasting, improved safety and reduced property damage, reduced stormwater runoff, travel time saving, and cost-savings from using improved technology) need to be categorized as benefits.

A BCA practitioner should exercise caution when dealing with transfer payments that arise from the policy action or project under consideration. According to OMB Circular A-4, "Transfer payments are monetary payments from one group to another that do not affect total resources available to society," or do not produce "any direct change in aggregate social welfare.""[52] To properly capture its impacts Circular A-4 suggests to exclude a transfer payment from the net benefits calculation and provide instead a separate analysis of the distributional impacts resulting from such transfer.[53] In this regard, the OMB Circular A-94 states that "there are no economic gains from a pure transfer payment

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[50] Categorizing impacts or outcomes as "inputs and outputs" is suggested here as a simplified approach to easily identify benefits and costs and group them accordingly. This however should not be confused with the distinctly different Input-Output Analysis commonly employed in economic impact analysis.
[51] Note that consequences of a policy change or action could potentially be positive or negative, resulting in positive or negative benefits, respectively. However, a negative benefit is not considered a cost in BCA.
[52] See OMB Circular A-4 (2003, pp.38, 46). When, under this approach, distinguishing between benefits or cost and transfer payments becomes difficult, it is recommended to reach out to OMB for case-by-case consultations.
[53] See OMB Circular A-4 (2003, p.38)

because the benefits to those who receive such a transfer are matched by the costs borne by those who pay for it."[54] Circular A-94 also suggests to separately report a description of the transfer (such as the parties affected, its nature and magnitude) and the corresponding distributional effects.

Once benefits and costs are properly categorized, we need to express them in monetary terms using appropriate prices. BCA practitioners can use market prices to monetize benefits and costs. But in many instances where market prices are unavailable, it is a common practice to use prices inferred from non-market methods and/or employ other approaches of estimating benefits and costs.[55]

Finally, to ensure transparency and reproducibility, it is necessary to comprehensively document the procedure employed in estimating the benefits and costs. This requires clearly stating the assumptions used, the problems encountered and the steps taken to resolve them as well as providing specific references to all sources of data, appendices and models used in the estimation of benefits and costs.

The next subsections discuss, more specifically, the procedures for estimating benefits and costs separately.

(a) Estimate benefits

As discussed above, benefits represent the monetized estimates of the potential impacts (or outcomes) identified as the direct or indirect outputs or consequences of the policy action or project under consideration. In other words, BCA should include, to the extent possible, the monetized value of all of the benefits reasonably expected to result from the policy action or project.[56] These benefits potentially accrue to affected individuals and/or entities and should be estimated and presented in the BCA on an annual basis during the analysis period.

Arithmetically, benefits are estimated by subtracting the estimated values of the potential impacts (or outcomes) under the baseline conditions from the corresponding values after the policy actions are undertaken. Hence, as any arithmetically obtained values, benefits could be either positive or negative. It should be noted that the interpretation of these positive and negative benefits depends

[54] See OMB Circular A-94 (1992, p.6)

[55] For example, Robinson, et al. (2019, pp. 10-13), U.S. DOT (2022, pp. 17-18) and U.S. EPA (2010, ch 7.3) describe various methods used to monetize benefits and costs. In contrast to market prices, imputing prices based on behaviors in the market (i.e., revealed preference) and using prices inferred from surveys (i.e., stated preference) are commonly used methods. In addition, such methods as damage costs and mitigation costs are other alternative approaches of accounting for benefits (or cost-savings) and costs.

[56] U.S. EPA (2010, ch 7) discusses in detail the processes for identifying and estimating benefits. In addition, FHWA (2012, pp.15, 97) and U.S. DOT (2022, pp.12-26) provide descriptions of project specific benefits.

primarily on the goal the policy action or project intends to achieve. This is illustrated in the examples below.

Positive benefits are achieved when, compared to the baseline period, the estimated values of the potential impacts (or outcomes) identified as measures of benefits show "*improvement*" after the policy actions are implemented. For example, for a policy action aimed at *ending overfishing and rebuilding stocks*, a *net increase* in the targeted fish population during the selected analysis period would be a positive benefit. In contrast, if the goal of the policy action is *reducing emissions* in order to improve, for instance, air quality and health status, achieving a *net decrease* in the level of emissions would generate a positive benefit.

Likewise, negative benefits are achieved when, compared to the baseline period, the estimated values of the potential impacts (or outcomes) identified as measures of benefits fail to show "improvement" after the policy actions are implemented.[57] For the above examples, a *net decrease* in the targeted fish population and a *net increase* in the level of emissions during the policy implementation period would be considered negative benefits. Note that a negative benefit accruing in a given year should not be considered as cost incurred in that year. Rather, a negative benefit accruing in year 5, for instance, should be subtracted from the total benefits in year 5.

(b) Estimate costs

As discussed above, costs denote the monetized estimates of the potential impacts (or outcomes) identified as measures of the inputs or resources needed to implement and operate the policy action or project and achieve the desired goals. Note that these costs represent only the "direct" expenditures (both financial and resources) during the policy implementation period or the life-cycle of the project under consideration. That means, we should avoid considering negative outcomes of a policy action as costs or improperly assigning negative benefits to costs.[58] The following are the main direct cost components commonly applicable to many policy actions or projects:[59]

- Capital costs: involve mostly upfront and non-recurrent expenditures required to implement the policy action or project.[60] Examples: the cost of land, equipment, and construction

[57] Sometimes, negative benefits are referred to as "disbenefits."
[58] Technically speaking, categorizing a given potential impact as a benefit or cost does not necessarily affect the BCA (as long as we are using the correct positive or negative sign when summing the benefits or costs). Nevertheless, improperly designating a cost item as a benefit, or vice versa, definitely affects the Benefit-Cost ratio (BCR) estimation by unnecessarily increasing or decreasing the values in the numerator or denominator of the BCR equation.
[59] See FHWA (2012, pp.15-16), U.S. DOT (2022, pp. 27-29) and U.S. EPA (2010, ch 8.2)
[60] In some instances, capital costs may be incurred across multiple years.

(including planning, designing, environmental review, materials, and construction/installation costs);

- Operating and maintenance costs: are recurrent expenditures necessary to operate and maintain the policy action or project (e.g., power, communications, labor, and routine maintenance costs);
- Replacement costs: refer to costs incurred to replace existing equipment that reaches the end of its useful life during the selected period of analysis.

Due to the fact that these costs are incurred at various times during the implementation period of the policy action or project, they need to be recorded in the year they are expected to be incurred and presented as annual estimates to use them in the BCA. That is, first we estimate the annual cost for each of the above cost components. Then, we sum these annual costs to obtain the total annual cost estimate for each year. For example, for year 3, we first estimate the annual capital cost (if any), operational and maintenance cost, and replacement cost (if any) separately. Then, we sum these components of annual costs together to obtain the total annual cost for year 3. We do the same for each year covered by the implementation period.

These costs are future costs that are expected to be incurred across multiple years during the implementation period of the policy action or project. This requires employing appropriate cost forecasting or projection methods by using reasonable assumptions about the timing and the cost distribution in accordance with the standard practices of the agency. Appropriately forecasting future costs is necessary to avoid resource shortfalls particularly for operating and maintenance as well as replacement costs.

Arithmetically, costs are estimated for each year of the analysis period by subtracting the estimated baseline costs from the expected costs of the policy action or project under consideration.
Similar to benefits, the resulting cost estimates could potentially be positive or negative. A positive net cost means an overall cost increase under the policy or project. But a negative cost for any given year indicates that the cost expected to be incurred under the policy or project is lower compared to the existing (baseline) costs. A good example for a negative cost would be less operating and maintenance costs for a new infrastructure during the policy or project implementation period than the aging and deteriorating infrastructure would require before the policy change or implementation of the project.

2.3.7 Discount future benefits and costs using appropriate discount rates

BCA involves comparing, in monetary terms, the streams of benefits and costs that occur over several years. To facilitate such comparison, the future values of benefits and costs should be expressed in present value terms. Discounting is the process of converting future values of money to present (or current-year) value. In effect, discounting accounts for the time value of money.[61] The underlying rationale for discounting is the fact that all decision makers (private and public entities) attach lower values to future benefits and current costs compared to present benefits and future costs, respectively. In other words, the general preference is to receive benefits early and incur costs later. Hence, to reconcile the difference in time preferences and undertake meaningful comparisons, both benefits and costs need to be discounted and expressed in present value terms. As such, discounting amounts to reducing future benefits and costs. Simply put, discounting expresses how much future benefits and costs are worth today.[62]

As discussed clearly in subsection 2.1(g), the OMB Circulars A-4 and A-94 provide the real discount rates appropriate for analyses of various government programs and projects. Accordingly, while Circular A-4 sets the real discount rate applicable only to regulatory impact analyses, Circular A-94 provides the real discount rates that apply to the analyses of regulatory and any other government programs (with some exception).[63] Therefore, it is incumbent upon BCA practitioners to choose the discount rate appropriate to the type of government program, project, or policy they are analyzing. Note also that the rates specified in both Circulars are subject for updates every 3 years starting from their first issuance date.

Discounting the streams of future real benefits and costs and then calculating their net present values (NPV) can be done in two ways. Note that the following approaches are versions of the same definitional formula for NPV calculation, namely, NPV is discounted benefits minus discounted costs.

(a) Estimating the present values of future benefits and costs separately, or

(b) Estimating the present value of the “net benefit” for each year.

It is worth to note that, as a third alternative approach, Appendix B-5 shows how NPV can be calculated without using either of the above mathematical formula-based approaches. Hence, practitioners may use the step-by-step illustrative example in Appendix B-5 as a guide for NPV

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[61] For details, see U.S. EPA (2010, ch 6); Koopmans & Mouter (2020, pp.13-16, 24); U.S. DOT (2022, p.9); Robinson, et al. (2019, pp. 26-31); OMB Circular A-4 (2003, pp. 31-34); OMB Circular A-94 (1992, pp. 8-11).

[62] For additional information on discounting, see Appendix B-1.

[63] See OMB Circular A-94 (1992, pp. 3-4).

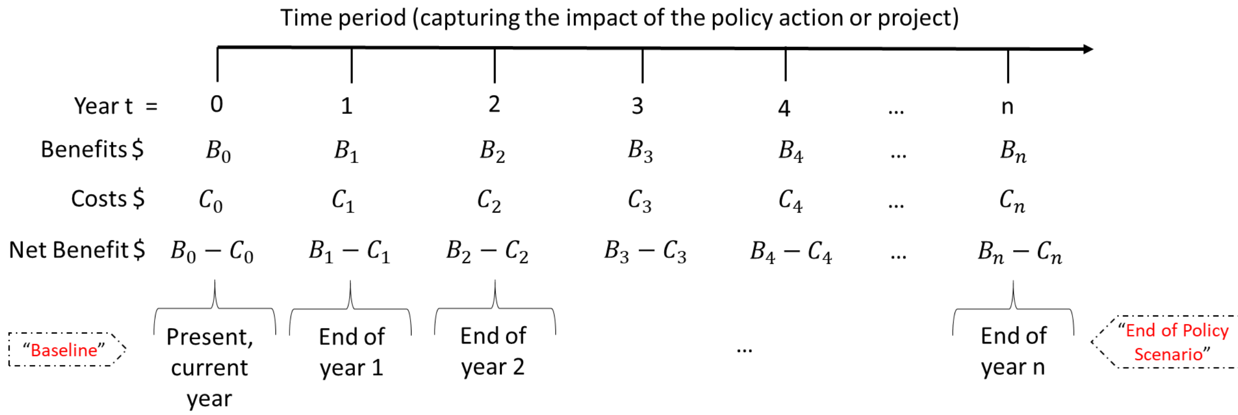
calculation using only the values for inflation adjustment and discounting provided in Appendix B-3 and Appendix B-4, respectively.

For the first approach, use Eq. 1 in Appendix B-2 to calculate the NPV of the stream of benefits and costs. That is, first the benefits accruing in each year should be discounted separately and summed to obtain the total discounted benefit over the life of the policy action or project. Similarly, the costs of the policy action or project incurred in each year should be discounted separately and summed to obtain the total discounted cost. Then subtracting the total discounted cost from the total discounted benefit gives the NPV of the policy action or project.

Eq. 1 is a preferred approach if the benefits and costs are occurring in different years during the policy action or project life. This refers to instances where a project may start incurring costs in the early years of the project while benefits may start accruing in the latter years.

An alternative approach for estimating NPV is discounting the net benefit for each year of the policy action or project using Eq. 2 or Eq. 3 in Appendix B-2. This approach requires both benefits and costs to occur in the same years. This is because, (i) the dollar amounts occurring in two different years represent different monetary values and hence cannot be subtracted from each other, and (ii) discounting is based on the years in which the benefits and costs are actually occurring. In this case, we can take the difference between the benefits and costs occurring in each year to obtain the net benefit (NB) for each year. Then, the NPV is estimated by discounting the NBs calculated for each year and summing them over the life of the policy action or project. Figure 3 shows how the benefits and costs are distributed over the life of the policy action or project and the corresponding discounting process.

Figure 3. Distribution of benefits and costs over the life of the policy action or project



$$NPV = \frac{(B_0 - C_0)}{(1+r)^0} + \frac{(B_1 - C_1)}{(1+r)^1} + \frac{(B_2 - C_2)}{(1+r)^2} + \frac{(B_3 - C_3)}{(1+r)^3} + \frac{(B_4 - C_4)}{(1+r)^4} + \cdots + \frac{(B_n - C_n)}{(1+r)^n}$$

$$NPV = NB_0 + \frac{NB_1}{(1+r)^1} + \frac{NB_2}{(1+r)^2} + \frac{NB_3}{(1+r)^3} + \frac{NB_4}{(1+r)^4} + \cdots + \frac{NB_n}{(1+r)^n}$$

where,

$B_0, B_1, B_2, B_3, \ldots, B_n$ denote benefits accruing in each year
$C_0, C_1, C_2, C_3, \ldots, C_n$ denote costs incurred in each year
$NB_0, NB_1, NB_2, NB_3, \ldots, NB_n$ denote the net benefit in each year

Figure 3 depicts the distribution of benefits and costs over the life of the policy action or project, showing net present value formulas.

Key Considerations:

- Discounting takes place using real monetary values (i.e., the benefits and costs in each year adjusted for inflation). Adjusting for inflation requires converting nominal dollar values to real dollar values using a common "base year" or "currency year" and a known deflator (or multiplier). Expressing all benefits and costs in the same "base year" helps to net out the effect of inflation over time. OMB Circular A-94 and OMB Circular A-4 recommend using the Gross Domestic Product (GDP) price deflator or Personal Consumption Expenditure (PCE) price index as the most appropriate and reliable inflation index to convert nominal dollars to real dollars.[64] Circular A-94 also suggests using alternative inflation estimates for sensitivity analysis.
- Note that inflation adjustment and discounting are two distinct processes. While inflation adjustment is necessary to remove the impacts of inflation and express benefits and costs in

[64] See OMB Circular A-94 (1992, p. 18-19) and OMB Circular A-4 (2003, p. 45). Consumer Price Index (CPI) and Producer Price Index (PPI) may also be used as alternative deflators or inflation adjustment factors under different circumstances. For GDP price deflators computed for different years, see Appendix B-3.

real monetary values (or in constant dollars), discounting is used to account for the time value of money and/or people's time preference.

- The sponsor of a BCA should determine what discount rate to use for the policy action or project under consideration.[65] OMB Circular A-94 recommends applying a real social discount rate of 7 percent[66] on all real monetary (or inflation adjusted) benefits and costs while analyzing specifically stated government programs, projects, or policies.[67] This means, at the 7 percent discount rate, the real value of a future dollar changes on average by 7 percent annually when converted to a present value. Note that OMB Circular A-4 also suggests using a 3 percent real discount rate to conduct a sensitivity analysis to show how the present value changes based on the choice of discount rates.[68]
- Generally, given the future value at time t (FV_t) and the discount rate (r), the present value (PV) can be calculated as:

$$PV = \frac{FV_t}{(1+r)^t} \quad \text{or} \quad PV = FV_t \times \frac{1}{(1+r)^t}$$

- It is necessary to make a distinction between a discount rate and a discount factor. As stated above, the discount rate (r) describes the average annual percentage change in a future dollar value. But the discount factor is a multiplier or weighting term used in a PV calculation. In the above equation, while r is the discount rate, $\frac{1}{1+r}$ is the discount factor. The discount factor is different for different years, showing how much value we assign to dollar values in each year. Hence, we develop a factor or weighting term for each year ($t = 0, 1, 2, ..., n$) using the formula $\frac{1}{(1+r)^t}$.

The graphs below show the discount factors developed using a 7 and 3 percent discount rates, $\left(\frac{1}{(1+0.07)^t}\right)$ and $\left(\frac{1}{(1+0.03)^t}\right)$, respectively, for 30 years in the future (i.e., $t = 0, 1, 2, ..., 30$). The results show that we place higher weights to the most recent years and less weights to years farther out in the future. This depicts our time preference for current values rather than for future values. For example, using a 7 percent discount rate, the

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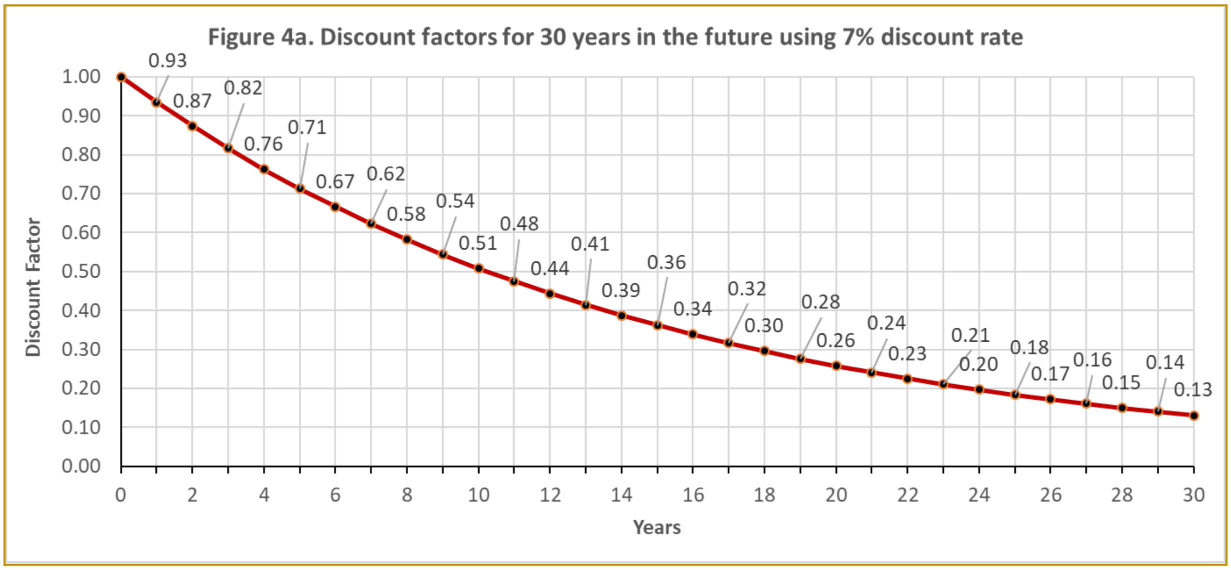
65 For detailed discussion on the different types of discounting, see for example, U.S. EPA (2010, ch. 6) and NASEM (2020, pp.10-11).
66 Note that a real discount rate is a rate that has been adjusted to eliminate the effect of expected inflation (i.e., a discount rate net of inflation).
67 See OMB Circular A-94 (1992, pp. 3-4) for the list of government programs, projects and policies to which the recommended discount rate is applicable.
68 See OMB Circular A-4 (2003, pp. 33-34). Appendix B-1 describes how OMB estimated the real discount rates.

benefits accrued or costs incurred in 1 year from now are weighted by a factor equal to 0.93, while the factor declines to 0.51 in 10 years or to 0.13 in 30 years from now.



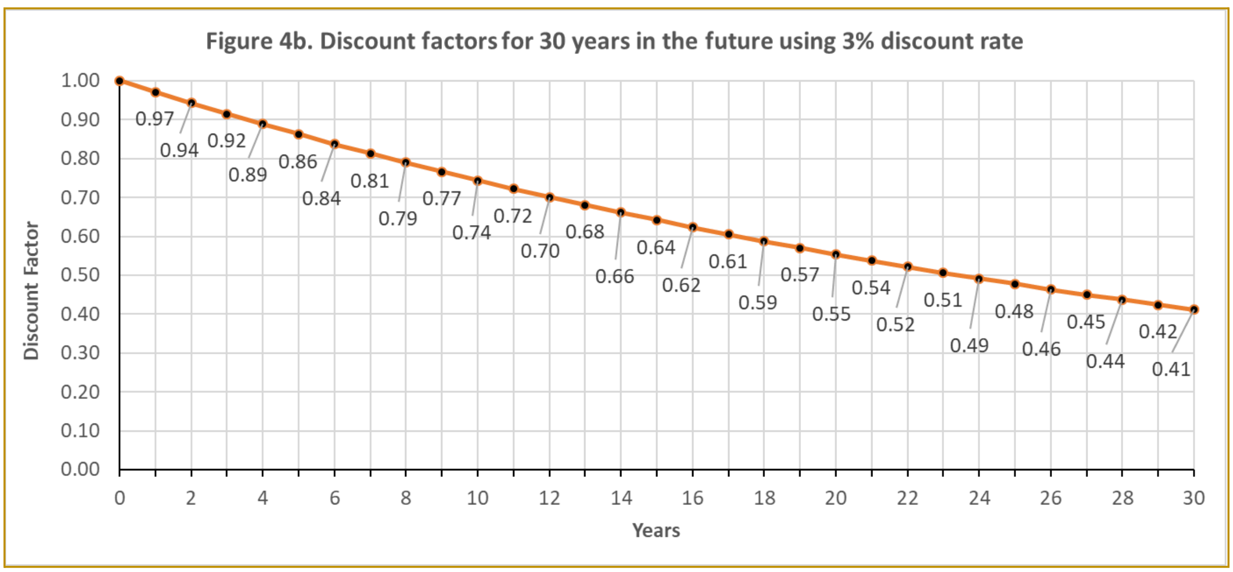


Figure 4a displays the discount factors for 30 years in the future asking a 7% discount rate.
Figure 4a displays the discount factors for 30 years in the future asking a 3% discount rate.

- The OMB Circular A-94 requires applying discount factors to monetary values expressed in real terms. In other words, all future benefits and costs should be adjusted for inflation prior to discounting them to estimate the PV.

Example: To estimate at 7 percent discount rate for the PV of a $10 million benefit (expressed in 2024 dollars) that will accrue 15 years from now, plug in the given values in the above PV equation:

$$PV = FV_{15} \times \frac{1}{(1+0.07)^{15}} = FV_{15} \times 0.36$$

Note: The discount factor 0.36 (at 7 percent discount rate) can also be read off the above graph (or Appendix B-4) for year 15.

Before multiplying the $10 million FV in year 15 by the discount factor 0.36, make sure that the $10 million value is adjusted for inflation using the appropriate base year.[69] If, for instance, 2022 is the base year, then use the appropriate inflation adjustment index of 0.9444 (the 2022 Index in Appendix B-3, Column 7 corresponding to 2024) to convert the $10 million (expressed in 2024 dollars) to the 2022 dollars. As shown in the calculation below, the $10 million benefit expressed in 2024 dollars becomes $9.444 million when converted to the 2022 dollar value. Then, multiply this 2022 inflation adjusted dollar value (i.e., $9.444) by 0.36 (the discount factor for year 15) to obtain $3.40 million (in 2022 dollars).

That is, $PV = (\$10\ million\ in\ 2024\ dollars\ converted\ to\ 2022\ dollars) \times 0.36$

$= (\$10\ million \times 0.9444,\ the\ 2022\ Index,\ Appendix\ B\_3) \times 0.36$

$= \$9.444\ million\ in\ 2022\ dollars \times 0.36$

$= \$3.40\ million\ in\ 2022\ dollars$

That means, the present value of the $10 million benefit (expressed in 2024 dollars) that will accrue in 15 years from now would be $3.40 million (expressed in 2022 dollars).

- An additional example illustrating the calculation of NPV without using any mathematical formulas is presented in Appendix B-5. The example shows a step-by-step approach for calculating NPV using only the values in Appendices B-3 and B-4 for inflation adjustment and discounting, respectively.

[69] Make distinction between a “base year” and a “baseline.” Base year (or currency year) is a year selected for inflation adjustment (or for reporting all real monetary values). Baseline refers to the reference year selected to evaluate the expected costs and benefits of a particular policy action or project (see subsection 2.3.3 for more details).

2.3.8 Compare benefits to costs

After the present value of benefits and costs have been estimated as discussed above, we need to compare them using standardized summary measures and report the analytical results to decision-makers. The most commonly used summary measures in BCA are:[70]

- Net benefits
- Benefit-to-cost ratio (BCR)
- Internal rate of return (IRR)

It should be noted that when using any of these summary measures, the present value of the benefits and costs should be estimated using the steps outlined in the preceding subsection. Generally, the selection of a summary measure depends primarily on the objective(s) the sponsor plans to achieve by conducting a BCA.[71]

The present value of net benefits (commonly denoted as net present value, NPV) may be preferred to explore potential alternatives and identify the policy action or project that is more efficient than others to address a particular problem.[72] Unlike the other two measures, estimating NPV includes all the potential benefits and costs over the life-cycle of the policy action or project under consideration.

The BCR is more frequently used to evaluate potential policy actions or projects under a budget constraint. Hence, BCR is the best approach if the primary goal is allocating limited resources across several policy actions or projects. BCR is estimated by dividing the present value of benefits by the present value of costs, but which components of benefits and costs to include in this calculation depends on the purpose of the BCA. In contrast, using IRR would be the best approach when the appropriate discount rate is uncertain or the primary focus is identifying financial investments with the highest monetary returns.[73] As such, the IRR is the process of estimating the discount rate at which the present value of net benefits (or NPV) is zero.

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[70] For these and other metrics that can potentially be used to summarize BCA results see, for example, NASEM (2020, pp.10-14).
[71] For more details see, for example, U.S. DOE (2014, pp. 4, 87), Robinson, et al. (2019, pp. 78-80), U.S. DOT (2022, pp. 29-30), and U.S. EPA (2010, p. A-14)
[72] See Rothenberg, J. (1969, p.45)
[73] It is called the internal rate of return because the rate is internal or intrinsic to the policy action or project under consideration and does not depend on anything except the resulting stream of revenues; see NIST (2003, p. 28). It is also called the rate of return over cost to emphasize on "the fact that different projects may have different sized resource commitments (costs);" see Rothenberg, J. (1969, p. 54)

This guidance mainly focuses on how to use net benefits in BCA[74] as directed by the OMB Circular A-4. This Circular states that net benefits can be used to "identify the alternative that maximizes net benefits."[75] By taking "the absolute difference between the projected benefits and costs" we can estimate the size of net benefits and use it to determine whether one policy action or project is more efficient than another. The Circular particularly advises not to use BCR because "the ratio of benefits to costs is not a meaningful indicator of net benefits" and hence "considering such ratios alone can yield misleading results"[76] because the largest BCR obtained for a given policy action or project may not always be the one that maximizes net benefits.

With regards to the IRR, the OMB Circulars A-4 and A-94 state that IRR "does not generally provide an acceptable decision criterion, and regulations with the highest internal rate of return are not necessarily the most beneficial."[77] However, for practitioners who prefer to use IRR as a meaningful or supplementary indicator in a regulatory analysis, the above Circulars advise to consider including the IRR results along with other calculated outcomes. I Accordingly, this guidance provides a detailed description of the estimation and use of IRR in Appendix B-6.

[74] Appendix B-6 provides a summary description of the estimation and use of BCR and IRR.
[75] See OMB Circular A-4 (2003, p. 10)
[76] See OMB Circular A-4 (2003, p. 10)
[77] See OMB Circular A-4 (2003, pp. 36-37) and OMB Circular A-94 (1992, p 9)

Text Box 6. Differences between BCA summary measures

	Net benefits	Benefit-to-cost ratio	Internal rate of return
Main use	Show magnitude of welfare gains; help compare projects and identify the one with the highest societal net benefits.	Does not show magnitude of welfare gains, but B/C ratios help prioritize spending across projects particularly when resources are limited.	Help identify financial investments with the highest monetary returns (compared to a given threshold, for example, OMB's discount rates)
Estimation	Subtract PV of costs from PV of benefits; include all potential benefits and costs	Divide PV of benefits to PV of costs; which benefits and costs to include depends on the goal of BCA. The example in Appendix B-6 gives more explanation.	Set the NPV formula to zero and solve for the discount rate (note that this is computationally challenging approach)
Estimation sensitivity	The magnitude of net benefits does not depend on how policy or project outcomes are categorized as benefits or costs (as long as correct signs are used)	Meaningful and comparable results can only be obtained if benefits or costs are consistently categorized across different policies or projects.	An estimated IRR is compared to a reference (threshold) rate of return for investment, which is not often readily available.
Drawbacks	Among policy alternatives with positive NPVs, the one with the highest net benefits is selected; but there is no threshold level of net benefits	Not an indicator of magnitude of impact; two projects with the same B/C ratio can have different NB estimates. Should be used in conjunction with other statistics	Uncertainty about the reference (or threshold) rate of return limits IRR's usefulness
OMB recommendation	Preferred measure to identify the policy action or project that maximizes net benefits	Not a meaningful indicator of net benefits; not recommended to use	No mention in the latest Circulars; Previous version Circulars described it as "not a preferred decision criterion," which can be used as a meaningful indicator if presented with other calculated outcomes

Text Box 6 lists the differences between BCA summary measures - net benefits, the benefit-to-cost ratio, and the internal rate of return.

We now return to the summary measure primarily recommended by OMB Circular A-4 (namely, net benefits). As discussed in subsection 2.3.7, comparing benefits and costs involves estimating the present value of the net benefits using either of the equations in Appendix B-1, as appropriate, and summarizing the final result for the entire analysis period as net present value (NPV). Using the sign and size of the NPV estimated for each alternative policy action or project under consideration, we can determine the alternative that maximizes net benefits.

- If the estimated NPV is positive (i.e., $NPV > 0$), then the policy action or project under consideration is said to be economically justified, because the benefits of the policy action or project indeed exceed all the associated costs (including the anticipated rate of return captured by the inclusion of the discount rate).
- To determine the alternative that maximizes net benefits from among all policy actions or projects with positive NPV, we compare the sizes of the estimated NPVs.
    - Obviously, the larger the size of the NPV, the greater is the dollar amount by which the estimated benefits exceed costs, and hence the more worthwhile is the policy action or project under consideration. As a result, the alternative with the largest NPV can potentially be selected as the one that maximizes net benefits.
    - However, due to the fact that the NPV is not likely to account for all potential benefits and costs as well as the difficulty associated with fully or partially quantifying and/or expressing some benefits or costs in monetary terms, the alternative selected with the largest NPV may not always be the one that maximizes net benefits.[78] In such instances, as per the OMB Circular A-4, " BCA is less useful, and it can even be misleading," because the estimated net benefits do not "provide a full evaluation of all relevant benefits and costs."[79]
    - In instances where non-quantified and/or non-monetized benefits or costs are believed to affect the ranking of alternatives based on estimated NPV, OMB Circular A-4 suggests the sponsor of a BCA to exercise their professional judgment in assessing the importance of the unquantified factors and providing a clear explanation to decision makers how the unquantified factors change the initial NPV-based ranking of alternatives.

In sum, the BCA summary measures discussed above are important quantitative tools that help select, among alternative policy actions or projects, the one that yields the largest net benefits to the targeted individuals and/or entities. Nevertheless, in addition to reporting the final BCA results using only these summary measures, it is extremely important to include as much descriptive information as possible about the legal and political requirements that played a role in framing the BCA as well as the budgetary constraints and the distributional concerns important to decision-makers.

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[78] See U.S. DOE (2014, p. 97)

[79] See OMB Circular A-4 (2003, p. 10)

2.3.9 Analyze risks and uncertainties

Quantitatively predicting the future benefits and costs of policy changes or projects is likely to involve varying levels of risks and uncertainties. These risks and uncertainties arise, for example, from the use of imperfect data and preliminary benefit and cost estimates, the difficulty associated with predicting the future demand for or supply of the resources required for the implementation of the policy change or project under consideration, and the inaccurate forecasts of exogenous variables such as economic growth, wage rates and inflation rates.[80]

The best approaches for minimizing the impacts of risks and uncertainties would be employing better data and prediction models, if possible, and “accepting and presenting” the risks and uncertainties when they are not avoidable.[81] The latter requires identifying the source of the risks and uncertainties, conducting sensitivity analysis[82] to assess their respective impacts on the BCA results, and including this information in the final report to sufficiently improve the basis for decision making.

For a proper treatment of the uncertainties inherent in benefit and cost estimates, the OMB Circular A-94 suggests that sponsors of BCA should explicitly identify and report the main sources of uncertainty, present expected value estimates, explore how results change with varying assumptions (sensitivity), and, when possible, provide probability distributions of benefits, costs, and net benefits.[83] These factors are elaborated further below.

Uncertainty should be clearly characterized. Ideally, this involves presenting probability distributions for the key outcomes. Objective probability estimates should be used where feasible, with market-based data—such as insurance payments or interest rate spreads—serving as useful indicators of risk. Stochastic simulation methods can aid in understanding these uncertainties. Analysts must explain the basis for their probability assumptions and acknowledge any limitations or biases in the data or approach.

Expected values should be calculated by weighting possible outcomes by their probabilities and summing them. These expected values serve as the most appropriate point estimates for costs,

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[80] See U.S. DOT (2022, p. 33). For more details see also OMB Circular A-4 (2003, pp. 39-42).
[81] See Koopmans & Mouter (2020, p. 24). U.S. EPA (2020, 84136) discusses the identification, explanation and presentation of uncertainties.
[82] Koopmans & Mouter (2020, p. 9) discuss other methods commonly used to address risks and uncertainties in BCA.
[83] See OM Circular A-94 (1992, pp. 11-12)

benefits, and net benefits. If alternative estimates, like worst-case scenarios, are provided, they must be accompanied by a clear rationale and an explanation of any potential biases.

Sensitivity analysis is also essential. Analysts should vary major assumptions and recalculate results, such as net present value, to assess how outcomes respond to changes. Key assumptions to examine depend on the primary drivers of cost and benefit and the most uncertain aspects of the program. For example, in a retirement program, relevant factors might include the number of beneficiaries, future wage growth, inflation, and the discount rate. Sensitivity analysis should generally include changes to estimates of benefits and costs, the discount rate, inflation, and distributional assumptions. The models used should be well documented and available for independent review whenever possible.

The overall goal of sensitivity analysis is to inform decision makers how the estimated benefits and costs change when the key assumptions, uncertain parameters, or alternative models used in the analysis change. Summarizing the above discussion, the OMB Circular A-4 suggests the following best practices to account for uncertainties:[84]

- Discuss qualitatively the main uncertainties in each input data used in the estimation of benefits and costs to show how the uncertainties in the data as well as in the analytical results affect the BCA results.
- Conduct a numerical sensitivity analysis to show how the BCA results vary with changes in assumptions, choices of input data, and alternative analytical approaches.
- Use appropriate statistical techniques (i.e., simulation models (e.g., Monte Carlo) and/or expert judgment (e.g., Delphi methods)) to estimate the probability distribution of the relevant uncertainties.

2.3.10 Conduct distributional analysis

Generally, BCA is a tool for identifying a policy action or project, among potential alternatives, that provides the largest benefits or rate of returns to a group of individuals or entities targeted by the policy action or project. BCA focuses on comparing the overall benefits of a policy action or project against the costs associated with implementing it with no or little consideration of how the benefits and costs are shared among the different social groups within the targeted population or entities. As a result, a project with the highest benefits or rate of return may result in making certain groups better off and others worse off. To capture such differential impacts, the most commonly used or

[84] See OMB Circular A-4 (2003, pp. 40-41)

recommended practice was to provide a separate description of distributional effects as a supplement to the main BCA results.[85] This shows that historically conducting distributional analysis was not part of the standard steps within the BCA framework.

However, more recently, conducting distributional analysis has become an integral part of BCA. Conducting distributional impacts of the BCA results across different groups of population is considered very important particularly in public policy decision making.[86] Distributional analysis can be used to show decision makers how the benefits and costs of the selected policy action or project are distributed among various social groups; e.g., traditionally underserved or disadvantaged communities, low-income groups, and minorities. It should be noted that such impact analysis would not affect the overall results of the BCA, but it provides important information that would help decision makers better understand the distributional impacts vis-à-vis the stated goals of the policy action or project under consideration.[87]

Depending on the type of population or entities a particular policy change or project under consideration targets, sponsors of BCA should consider conducting a close examination of the effects of the BCA results on various sub-populations, social groups or geographic locations. In cases where quantitative impact analysis is not feasible, sponsors of BCA are encouraged to provide, at minimum, a qualitative description of the distribution of the benefits and costs as well as the BCA results (i.e., net benefits, BCR or IRR) among relevant sub-groups within the population or entities targeted by the policy action or project. For example, the National Marine Fisheries Service (NMFS) has a policy directive to conduct social impact assessments that contain distributional assessment and community level effects. To guide the social impact assessment process, the NMFS has also developed a handbook for fisheries practitioners.[88]

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[85] See, for example, OMB Circular A-4 (2003, p.14).
[86] See OMB Circular A-4 (2003, p. 14)
[87] For more details and examples, see Robinson, et al. (2019, pp. 62-72) and U.S. DOT (2022, p.31).
[88] See Clay and Colburn (2020)

Appendices

Appendix A: Examples of NOAA BCA applications

NOAA provides a wide range of products and services to society. Below are some examples of BCAs that have been carried out to compare the magnitude of the benefits and costs associated with providing products and services to society.

Appendix A-1. Benefit-Cost Analysis of the G550 Procurement

Information benefits are benefits from the provision of knowledge that is useful for decision making, such as the lead times that are provided ahead of extreme weather events, which reduce the potential impacts from those events. OMAO and NOAA's Chief Economist Team used OMB's Circular A-4 as a guide to address OMB's request to estimate the costs of procuring operational capability for the G550 "Hurricane Hunter" aircraft and the anticipated benefits of the G550 to hurricane prediction. As a baseline, which is a requirement of Circular A-4, the team used the current track forecast error for the 72-hour forecast, which is 100 nautical miles. The team also estimated the costs and benefits of six alternatives to the purchase of the G550. A high-quality BCA requires detailed information on costs and benefits. Fortunately, OMAO was able to provide detailed cost information for the G550 and its alternatives. It was also able to provide a breakdown of costs for different instruments and a schedule of when those costs would be incurred. Major cost items that were included in the analysis for the G550 and/or its alternatives included acquisition costs, modification costs, lease, rental, contract, and operational costs, additional instrumentation costs, such as installation and calibration costs.

The BCA focused on three important classes of benefits (measured as reduced costs) due to improved forecasts:

- Reducing household evacuation costs
- Reducing hospital evacuation costs
- Reducing costs of shutting down petroleum refineries

To conduct BCA, it was also necessary to clearly articulate the differences in capabilities between the alternatives. These differences generally need to be defined from the perspective of the decision makers who use NOAA's information to improve outcomes for society, and generally these are people outside of NOAA. In this case, decision makers use information about the expected location and severity of hurricanes.

Appendix A-2. Framework Adjustment 33

NMFS's interim final rule Fisheries of the Northeastern United States: Framework Adjustment 33 to the Atlantic Sea Scallop Fishery Management Plan (FR Vol. 86, No. 95, May 21, 2021)[89] approves

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[89] Interim final rule Fisheries of the Northeastern United States: Framework Adjustment 33 to the Atlantic Sea Scallop Fishery Management Plan (FR Vol. 86, No. 95, May 21, 2021). https://www.govinfo.gov/content/pkg/FR-2021-05-19/pdf/2021-10553.pdf

and implements the Framework Adjustment 33 to the Atlantic Sea Scallop Fishery Management Plan[90] developed by the New England Fishery Management Council (henceforth the Council). The purpose of this action is to set scallop specifications and other measures for fishing years 2021 and 2022, implement measures to protect small scallops, and to reduce bycatch of flatfish. This action is intended to prevent overfishing and improve both yield-per-recruit and the overall management of the Atlantic sea scallop resource. Framework 33 includes, among others, a final environmental assessment that describes the management measures that need to be adjusted and a range of alternatives considered to achieve the goals and objectives of the proposed action, and analyzes the impacts of these measures and alternatives.

Framework 33 considered a set of actions or management measures:

Action 1: Overfishing Limit (OFL) and Acceptable Biological Catch (ABC)
Action 2: Northern Gulf of Maine Total Allowable Catch (TAC) Setting
Action 3: Fishing Year 2021 & 2022 Specifications and Rotational Management
Action 4: Access Area Trip Allocations to the limited access general category (LAGC) individual fishing quota (IFQ) Component
4.1 Select Northern Gulf of Maine TAC for FY 2021
4.2 Select Northern Gulf of Maine TAC for FY 2022
Action 5(a): Research Set-Aside (RSA) Compensation Fishing
Action 5(b): Seasonal Closure of Closed Area II Access Area to Reduce Impacts on Georges Bank Yellowtail Flounder and Northern Windowpane Flounder

Each of these actions is analyzed primarily under at least two alternatives, the first of which is the “no action” alternative and the remaining alternative(s) refers to “undertaking the proposed action.” With the exception of the “no action” alternative, each of the alternatives is further analyzed under a number of options or scenarios. The Council conducted a cumulative effects analysis (CEA) to determine the expected combined impacts of the proposed actions on the valued ecosystem components (VECs) for the the federally managed Atlantic sea scallop fishery. The VECs are the places where the impacts of the proposed management actions are expected to occur,which include:

- Target Species (Atlantic sea scallop, Placopecten magellanicus)
- Non-target species
- Physical environment / Essential Fish Habitat
- Protected species
- Human communities – Economic Impacts and Social Impacts

The CEA identifies and characterizes the incremental direct and indirect impacts on the VECs by the alternatives under consideration when analyzed in the context of other past, present, and reasonably foreseeable future actions. When an alternative has a positive impact on the VEC (e.g., reduced fishing mortality on a managed species), it has a positive cumulative effect on the stock size of the species when combined with “other” actions that were also designed to increase stock size. In contrast, when an alternative has negative effects on a VEC (such as increased mortality), the cumulative effect on the VEC would be negative and tend to reduce the positive effects of the other actions. Then, the preferred

[90] New England Fishery Management Council. (April 7, 2021). Scallop Fishery Management Plan: Framework Adjustment 33 to the Atlantic Sea Scallop Fishery Management Plan. https://d23h0vhsm26o6d.cloudfront.net/210407-Framework-33-Final-Submission.pdf

alternatives were identified based on the magnitude and significance of the resultant positive and negative cumulative effects on each VEC.

The Council also conducted benefit-cost analysis (BCA) to evaluate the short- and long-term economic impacts of the management alternatives considered in Framework 33. Benefits are estimated based on changes in consumer and producer surpluses and fishing revenues generated following the implementation of the proposed management actions. Costs include all expenditures attributed to the proposed management actions as well as forgone revenues by the fishing industry due to reduced landings in the short-run. In addition, the Council analyzed the social impacts of the proposed management actions by using factors or variables that help describe the scallop fishery, including:

- Size and demographic Characteristics of the fishery-related workforce residing in the area
- Attitudes, beliefs, and values of fishermen, fishery-related workers, other stakeholders and their communities
- Effects of the proposed action on Social Structure and Organization
- Non-economic social aspects of the proposed action
- Historical dependence on and participation in the fishery by fishermen and communities

These factors or variables are considered relative to the management alternatives and used as the bases for comparison between alternatives.

Appendix A-3. Benefits of the Digital Coast

The Digital Coast[91] is a website that provides data, tools, and training on coastal management issues. The website is managed by NOAA's Office for Coastal Management (OCM). The users of Digital Coast include coastal managers from regional governance organizations, the federal government, academia, NGO/nonprofit/volunteer groups, municipal/county/parish governments, and state/territorial governments. These users rely on Digital Coast for information related to climate adaptation, coastal conservation, land use planning, coastal hazard mitigation, natural resources management, and water quality management, among others.

Given the wide array and volume of resources available in Digital Coast, it is challenging to evaluate all benefits of the website to society. For this reason, a 2021 study of the societal value of Digital Coast[92] selected a subset of products for analysis, and conducted case studies to estimate the economic benefits of these products in meeting specific needs. Two products that were studied were the Sea Level Rise Viewer and Coastal Flood Exposure Mapper, which are tools that allow coastal management stakeholders to identify locations that have communities and natural resources exposed to coastal flood hazards.

This study was not done to address OMB requirements and thus did not follow Circular A-4 guidelines. In addition, it did not estimate the costs of making the Digital Tools available to decision

[91] See https://coast.noaa.gov/digitalcoast/

[92] Cleary, K., Krupnick, A., Villaneuva, S, with Thompson, A. "The Social Value of NOAA's Digital Coast." Report 21-03. (February 2021). https://media.rff.org/documents/RFF_WP_21-03.pdf

makers. However, the study is a good example of the use of an alternative scenario to provide a meaningful measure of benefits: it compared the results of a decision made with the aid of Digital Coast to an alternative scenario in which Digital Coast was assumed to not have been available. Because the alternative scenario is uncertain, the authors varied the assumptions in that scenario to account for uncertainty and provide a range of values.

The decision that was considered in the study was the relocation and consolidation of three wastewater treatment plants in Jackson County, Mississippi. The Jackson County Utility Authority (JCUA) decided to relocate and consolidate the plants in a location above the floodplain to avoid flooding impacts from future hurricanes. The Sea Level Rise Viewer and Coastal Flood Exposure Mapper helped identify sites with minimal risk from storm surge, flooding, and sea level rise to help ensure a safe long-term location. Design planning for the new facility began in 2018. The new location has not been selected, but all of the sites under consideration meet the expectations for low flooding risk. The new plant is expected to be operational by 2030.

Interviews were conducted to determine how JCUA staff used the Digital Coast tools in the process of planning the relocation of the plants, and it was determined that, without the tools, professional help would have been required as an alternative to identifying low-risk sites. This would have required more time to make decisions regarding a new site. JCUA staff estimated that the use of the Digital Coast tools saved approximately one to two years in planning efforts. Therefore, the benefits of the Digital Coast tools were estimated as the avoided damages from hurricanes resulting from relocating the plants one to two years earlier. The authors used historical data to estimate the probability that a hurricane of a given intensity would make landfall on the Mississippi coastline each year, and accounted for climate change scenarios in their models. Using a 2% discount rate, the study estimated that the avoided damages from the use of the Digital Coast tools were approximately $1,117,000 for one year of avoided damages and $2,213,000 for two years of avoided damages), in 2014 dollars.

Appendix B. Discounting and important costs and statistics

Appendix B-1. More information on discounting

Discounting future benefits and costs to determine their present value in today's dollars is a central feature of benefit-cost analysis. The total benefit of an investment is not simply the sum of benefits over the life of the project, nor is the total cost the sum of costs. This is because a dollar received or paid in the future is innately worth less than a dollar received or paid in the future by both individuals and business entities. The same is true for costs. Comparing benefits or costs that are realized at different times is like adding apples and oranges.

Individuals and businesses prefer to receive benefits sooner and pay costs later. This "time preference" for consumers can be thought of as their ability to earn interest by saving instead of spending; a dollar received today can be invested and that investment will be worth more next year, and much more 20 years from now. The time preference for businesses is linked to their ability to grow their business by investing in it. This concept should also be considered when deciding to take a lump sum or annuity payment for lottery winnings.

The body of research on discounting is vast and many issues are unresolved. However, for regulatory impact analysis or infrastructure investments by the U.S. Federal government, OMB, estimated the "social rate of time preference" to be 3 percent. This rate captures "the rate at which society discounts future consumption flows to their present value."[93] OMB also estimated the investment rate of return to be 7 percent, which approximately denotes "the marginal pretax rate of return on an average investment in the private sector."[94] These discount rates serve as upper and lower bounds for estimating the value today of a stream of benefits or costs that are realized in the future. Because of the discrepancies in regulatory impacts on capital and consumption, OMB Circular A-4 recommends that "any agency that wishes to tackle this challenging analytical task should check with OMB before proceeding."[95]

As noted earlier, BCA practitioners should choose a discount rate appropriate to their programs or projects being analyzed as per recommendations in the OMB Circulars A-4 and A-94. The consistent and appropriate use of the above two rates by Federal agencies allows OMB to fairly consider tradeoffs between Federal expenditures in a diverse array of products and services, ranging from transportation and education to satellites, weather forecasting, and fisheries management.

Appendix B-2. Mathematical formulation of the discounting process

(a) To estimate the present values of future benefits and costs separately, use the following equation:

$$NPV = \sum_{t=0}^{n} \frac{B_t}{(1+r)^t} - \sum_{t=0}^{n} \frac{C_t}{(1+r)^t}$$

Eq. 1

$$NPV = \left[\frac{B_0}{(1+r)^0} + \frac{B_1}{(1+r)^1} + \frac{B_2}{(1+r)^2} + \ldots + \frac{B_n}{(1+r)^n}\right] - \left[\frac{C_0}{(1+r)^0} + \frac{C_1}{(1+r)^1} + \frac{C_2}{(1+r)^2} + \ldots + \frac{C_n}{(1+r)^n}\right]$$

where,

B_t denotes the benefits accruing in year $t = 0, 1, 2, \ldots, n$ (over the policy action or project life);

C_t denotes the costs incurred in year $t = 0, 1, 2, \ldots, n$;

r denotes the discount rate (assuming the same rate is applied over the project life).

Note that estimating the NPV using Eq. 1 applies when benefits and costs are occurring in different years during the policy action or project life.

(b) To estimate the present value of the "net benefit" for each year of the policy action or project, use the following alternative approach:

[93] See OMB Circular A-4 (2003, p. 33)
[94] See OMB Circular A-94 (1992, p. 9)
[95] See OMB Circular A-4 (2003, p. 33)

By definition, net benefit in any given year (NB_t) is the difference between the benefits and costs in that year. Hence, rewriting Eq.1 gives:

$$NPV = \sum_{t=0}^{n} \frac{(B_t - C_t)}{(1+r)^t}$$

Eq. 2

$$NPV = \frac{(B_0 - C_0)}{(1+r)^0} + \frac{(B_1 - C_1)}{(1+r)^1} + \frac{(B_2 - C_2)}{(1+r)^2} + ... + \frac{(B_n - C_n)}{(1+r)^n}$$

where, $(B_t - C_t)$ denotes the net benefit (NB_t) in each year $t = 0, 1, 2, ..., n$.

Eq. 2 can equivalently be written as:

$$NPV = \sum_{t=0}^{n} \frac{NB_t}{(1+r)^t}$$

Eq. 3

$$NPV = \frac{NB_0}{(1+r)^0} + \frac{NB_1}{(1+r)^1} + \frac{NB_2}{(1+r)^2} + ... + \frac{NB_n}{(1+r)^n}$$

Note that estimating the NPV using either Eq. 2 or Eq. 3 requires both benefits and costs to occur in the same years.

Appendix B-3. Implicit Price Deflators for Gross Domestic Product (GDP)

Year	GDP Deflator	Index (2017 = 100)	Index (2019 = 100)	Index (2020 = 100)	Index (2021 = 100)	Index (2022 = 100)	Index (2023 = 100)
2000	72.722	0.7272	1.4298	1.4488	1.5150	1.6230	1.6814
2001	74.360	0.7436	1.3983	1.4169	1.4816	1.5872	1.6443
2002	75.515	0.7552	1.3769	1.3952	1.4589	1.5629	1.6192
2003	77.006	0.7701	1.3503	1.3682	1.4307	1.5327	1.5878
2004	79.077	0.7908	1.3149	1.3324	1.3932	1.4925	1.5463
2005	81.556	0.8156	1.2749	1.2919	1.3509	1.4472	1.4993
2006	84.071	0.8407	1.2368	1.2532	1.3105	1.4039	1.4544
2007	86.349	0.8635	1.2042	1.2202	1.2759	1.3668	1.4160
2008	88.013	0.8801	1.1814	1.1971	1.2518	1.3410	1.3893
2009	88.556	0.8856	1.1742	1.1898	1.2441	1.3328	1.3807
2010	89.632	0.8963	1.1601	1.1755	1.2292	1.3168	1.3642
2011	91.481	0.9148	1.1366	1.1517	1.2043	1.2902	1.3366
2012	93.185	0.9319	1.1158	1.1307	1.1823	1.2666	1.3122
2013	94.771	0.9477	1.0972	1.1117	1.1625	1.2454	1.2902
2014	96.421	0.9642	1.0784	1.0927	1.1426	1.2241	1.2681
2015	97.316	0.9732	1.0685	1.0827	1.1321	1.2128	1.2565
2016	98.241	0.9824	1.0584	1.0725	1.1214	1.2014	1.2446
2017	100	1.0000	1.0398	1.0536	1.1017	1.1803	1.2227
2018	102.291	1.0229	1.0165	1.0300	1.0770	1.1538	1.1953
2019	103.979	1.0401	1.0000	1.0133	1.0596	1.1351	1.1759
2020	105.361	1.0538	0.9869	1.0000	1.0457	1.1202	1.1605
2021	110.172	1.1021	0.9438	0.9563	1.0000	1.0713	1.1098
2022	118.026	1.1797	0.8810	0.8927	0.9335	1.0000	1.0360

2023	122.273	1.2227	0.8504	0.8617	0.9010	0.9653	1.0000
2024	125.230	1.2523	0.8303	0.8413	0.8798	0.9425	0.9764

Appendix B-3 lists the implicit price deflators for Gross Domestic Product.
Source for GDP deflators: Bureau of Economic Analysis, National Income and Product Accounts (NIPA), Table 1.1.9. Implicit Price Deflators for Gross Domestic Product (last revised: March 27, 2025).

Notes:
- BEA estimated the GDP Deflators using 2017 as a base year (i.e., 2017 =100). For ease of multiplication, the Index for 2017 in column 3 is estimated by dividing each year's GDP deflator by the base year (2017) GDP deflator.
- But most commonly, we want to express monetary values in any other year appropriate for the project being undertaken. For example, to express all the monetary values in terms of 2023 dollars, we can use the Indices for 2023 in column 8, estimated by dividing the 2023 GDP deflator by the GDP deflators in each year. The Indices for converting to 2019, 2020, 2021 or 2022 dollars are estimated likewise.

Example: If the expenditure on a given project was $2 million in 2018 dollars, multiply it by 1.0165, 1.0300, 1.0770, 1.1538 or 1.1953 (the 2019, 2020, 2021, 2022 or 2023 Indices in column 4, 5, 6, 7 or 8, respectively, corresponding to 2018) to express it in 2019, 2020, 2021, 2022 or 2023 dollars. That is,

$$\$2\ million\ in\ 2018\ dollars \times 1.0165 = \$2.0330\ million\ in\ 2019\ dollars$$
$$\$2\ million\ in\ 2018\ dollars \times 1.0300 = \$2.0600\ million\ in\ 2020\ dollars$$
$$\$2\ million\ in\ 2018\ dollars \times 1.0770 = \$2.1541\ million\ in\ 2021\ dollars$$
$$\$2\ million\ in\ 2018\ dollars \times 1.1538 = \$2.3077\ million\ in\ 2022\ dollars$$
$$\$2\ million\ in\ 2018\ dollars \times 1.1953 = \$2.3907\ million\ in\ 2023\ dollars$$

Appendix B-4. Discount factors over the next 30 years at 7% and 3% discount rates

Discount Rate (r)	7%	3%
(1+r)	1.07	1.03
Year (t)	Discount Factor $\left(\frac{1}{(1+r)^t}\right)$	
0	1.00	1.00
1	0.93	0.97
2	0.87	0.94
3	0.82	0.92
4	0.76	0.89
5	0.71	0.86
6	0.67	0.84

7	0.62	0.81
8	0.58	0.79
9	0.54	0.77
10	0.51	0.74
11	0.48	0.72
12	0.44	0.70
13	0.41	0.68
14	0.39	0.66
15	0.36	0.64
16	0.34	0.62
17	0.32	0.61
18	0.30	0.59
19	0.28	0.57
20	0.26	0.55
21	0.24	0.54
22	0.23	0.52
23	0.21	0.51
24	0.20	0.49
25	0.18	0.48
26	0.17	0.46
27	0.16	0.45
28	0.15	0.44
29	0.14	0.42
30	0.13	0.41

Appendix B-5. NPV calculation using only table values

The hypothetical example below illustrates how NPV can be calculated using only the discount factors shown in Appendices B-4, i.e., without using the mathematical formulas in Eq. 1 through Eq. 3.

(Million $)

Calendar Year	Project Year (t)	Estimated Benefits (2020 dollars)	Construction & Maintenance Costs* (2020 dollars)	Discount Factors at 7%**	PV of Benefits (Discounted at 7%)	PV of Costs (Discounted at 7%)	NB at 7%
		A	*B*	*C*	*D = A × C*	*E= B × C*	*F= D –E*
2021	1	$0	$45	0.93	$0.00	$42.06	-$42.06
2022	2	$0	$20	0.87	$0.00	$17.47	-$17.47
2023	3	$0	$0.1	0.82	$0.00	$0.08	-$0.08
2024	4	$0	$0.3	0.76	$0.00	$0.23	-$0.23

2025	5	$16.5	$0.5	0.71	$11.76	$0.36	$11.41
2026	6	$18.7	$0.6	0.67	$12.46	$0.40	$12.06
2027	7	$25.3	$0.7	0.62	$15.76	$0.44	$15.32
2028	8	$31.6	$0.8	0.58	$18.39	$0.47	$17.93
2029	9	$26.8	$0.9	0.54	$14.58	$0.49	$14.09
2030	10	$25.4	$1.0	0.51	$12.91	$0.51	$12.40
Total					**$85.86**	**$62.45**	**$23.37**

* The initial costs in the first 2 years are construction costs, while the costs in the rest of the years denote maintenance costs.

**The column shows the discount factor at 7% discount rate for each project year (see Appendix B-4).

Description:

- Discounting is applied to real monetary values. In this example, all the future benefits and costs are expressed in the same base year or "currency year" (i.e., in 2020 dollars). If you choose to report the BCA results in 2020 dollars, there is no need to adjust for inflation.
- To calculate the present value (PV) of the benefits or costs in year-1 at a 7% discount rate, multiply the corresponding estimated benefits or costs by the discount factor of 0.93 for the same year (taken from Appendix B-4). Do the same for the rest of the project years.
- To calculate the net benefit (NB) for each year, subtract the PV of costs (Column E) from the PV of benefits (Column D) for the corresponding year. NBs are negative in the first 4 years due to relatively large amounts of construction costs incurred upfront before the project starts generating any benefits.
- Sum the NBs in Column F to obtain a net present value (NPV) of $23.37 million (in 2020 dollars) for the analysis period under consideration (i.e., 10 years for this example).
- It is also possible to report the results of the BCA in any other base or "currency" year of your choice. If, for instance, you choose 2021 as your base year:
  - (a) First convert the benefits and costs expressed in 2020 dollars to 2021 dollars. To do so, multiply each value in Columns A or B by **1.0457** (the 2021 Index in Appendix B-3, Column 6 corresponding to 2020).
  - (b) Then, repeat the steps in Columns D through F in the table above to obtain the NPV in 2021 dollars. As shown below, the NPV becomes $24.55 million in 2021 dollars.

(Million $)

Calendar Year	Project Year (t)	Estimated Benefits (2021 dollars)	Construction & Maintenance Costs* (2021 dollars)	Discount Factor at 7%**	PV of Benefits (Discounted at 7%)	PV of Costs (Discounted at 7%)	NB at 7%
		A	*B*	*C*	*D = A × C*	*E= B × C*	*F= D –E*
2021	1	$0	$47.06	0.93	$0	$43.76	-$43.76
2022	2	$0	$20.91	0.87	$0	$18.20	-$18.20
2023	3	$0	$0.10	0.82	$0	$0.09	-$0.09
2024	4	$0	$0.31	0.76	$0	$0.24	-$0.24

2025	5	$17.25	$0.52	0.71	$12.25	$0.37	$11.88
2026	6	$19.55	$0.63	0.67	$13.10	$0.42	$12.68
2027	7	$26.46	$0.73	0.62	$16.40	$0.45	$15.95
2028	8	$33.04	$0.834	0.58	$19.70	$0.49	$18.68
2029	9	$28.02	$0.94	0.54	$15.13	$0.51	$14.63
2030	10	$26.56	$1.05	0.51	$13.55	$0.5377	$13.01
Total					**$89.60**	**$65.05**	**$24.55**

* The initial costs in the first 2 years are construction costs, while the costs in the rest of the years denote maintenance costs.
**The column shows the discount factor at 7% discount rate for each project year (see Appendix B-4).

Appendix B-6. Estimation and use of BCR and IRR

(a) Estimation and use of Benefit-to-Cost Ratio (BCR)

BCR is estimated by dividing the present value of benefits by the present value of costs. As discussed in subsection 2.3.8, the OMB Circular A-4 does not recommend using BCR as a preferred measure because using such measure *alone* yields "misleading results."[96] It is well known that, if the criterion is maximizing net benefit, an alternative project with the largest BCR "does not necessarily" represent the one with the largest net benefits.

For example, consider two mutually exclusive projects (assuming away risks and uncertainties), one with a benefit of $5,000 and a cost of $1,250, the other with a benefit of $17,000 and a cost of $4,750 (all expressed as PVs). Although the first project has the largest BCR of 4 compared to a BCR of 3.6 for the second project, the net benefit of the first project ($3,750) is much lower than that of the second project ($12,250). Such discrepancy that arises when using net benefits and BCR for comparing alternative projects for identifying the one that ascertains the "most effective use of economic resources," has long been the point of debates among economists and BCA practitioners.[97] The compromise resulting from the debates seemed to have boiled down to employing a practical approach developed based on the basic economics assumptions: "capital resources are limited" and the objective of conducting a BCA is "maximizing net returns."[98] Consequently, the contradictory results obtained from using net benefits and BCR can be easily resolved "if the benefit-cost ratio be calculated, not as a gross figure representing all costs and all benefits, but in such a way as to separate capital costs from running costs and

[96] See OMB Circular A-4 (2003, p. 10)
[97] Hammond, R. (1966) provides a comprehensive review of the use and limitation of BCA in general and issues related to BCR estimation and use in particular.
[98] Hammond, R. (1966, p. 202)

exclude the latter from the denominator of the ratio."[99] As illustrated in the example below, such calculations are not only "correct and intelligible," but also ensure that "the projects having the highest ratio will also show the maximum net benefit."[100]

More specifically, the calculations described above (or the *corrected approach*) can be expressed using the notations used in this guidance as follows:

$$BCR = \frac{PV\ of\ Benefits - PV\ of\ Operating\ \&\ Maintenance\ Costs}{PV\ of\ Capital\ or\ Investment\ Costs} \quad \text{Eq. 4}$$

The BCR estimation differs from the net-benefit estimation in the components of benefits and costs that would be included in its calculation. As discussed in subsection 2.3.6(b), the total cost of any policy change or project is estimated as:

$$Total\ Cost = Capital\ Cost + Operating\ and\ Maintenance\ Costs + Replacement\ Costs$$

However, in the above BCR calculation, "operating and maintenance costs" are excluded from the total cost in the denominator and the same amount is subtracted from the total benefits in the numerator.[101] This, of course, contrasts with the customary manner of computing BCR:

$$BCR = \frac{PV\ of\ Benefits}{PV\ of\ Costs} \quad \text{Eq. 5}$$

where the *PV of Costs* is the sum of all costs of the project (capital, operating and maintenance, and replacement costs). As discussed above (and shown in the example below), using this latter approach does not always help identify the project with the largest net benefits.

Example: Comparing BCR estimations using the customary vs. corrected approaches

	Project 1	Project 2
PV of Benefits	$5,000	$17,000
PV of Costs	$1,250	$4,750

[99] See Hammond, R. (1966, p. 202). A similar version of this approach is incorporated in recent impact evaluation documents, see for example, U.S. DOE (2014, p. 87; note the definitions of investment costs and benefits in Table II.7-1) and Robinson, et al. (2019, pp. 78-80)
[100] See Hammond, R. (1966, p. 202)
[101] The BCA guidance developed by DOT recommends this approach specifically for projects to be undertaken under the Discretionary Grant Programs; see U.S. DOT (2022, p. 30).

Net Benefits	$3,750	$10,250
BCR (using Eq. 5)	4.0	3.6
***Decision 1**: Based on BCR, Project 1 would be selected despite its lower net benefits*		
Operating & Maintenance (O&P) Costs	$350	$2,000
PV of Benefits, less O&M Costs	$4,650	$15,000
PV of Costs, less O&M Costs	$900	$2,750
BCR (using Eq. 4)	5.2	5.5
***Decision 2**: Based on BCR or Net Benefits, Project 2 would be selected. The project with the largest BCR is now the one with the largest Net Benefits.*		

As a concluding remark, we present two cases where BCR is particularly useful for project evaluation. The first relates to the more frequent use of BCR when choosing projects under a budget constraint. This means that given a fixed budget, our task is selecting a number of projects (i.e., not only one project) from among alternative options based on a BCR criterion. Obviously, using such a criterion is not likely to be helpful in selecting a single project with the largest net benefits, nevertheless this approach is useful for prioritizing projects and identifying the ones that yield the largest possible net returns given a fixed budget. In this case, the most commonly used approach is sorting the projects in decreasing order of their BCRs and allocating the required funds accordingly until the available budget is exhaustively used.[102]

The second specific case where the standard estimation of BCR becomes readily useful is when the Net Benefits approach fails to identify a project with the largest net benefits. One such case is when we are faced with two projects having the same net benefits, but with different costs. If net benefits is the only criterion, these projects would be equally desirable. However, due to their differing costs, calculating BCR using Eq. 5 would handily help select the project that yields the highest benefit or return for a $1 cost incurred.

[102] See U.S. EPA (2010, p. A-14) for detailed discussion and illustration of the BCR approach in footnote 31.

(b) Estimation and use of Internal Rate of Return (IRR)

Estimation of IRR is a process of identifying the discount rate that yields the highest monetary returns to the financial investments under the planned project. In this regard, IRR can be considered as a measure of profitability or investment efficiency. Using the OMB-prescribed 3.1 percent real discount rate in an NPV calculation is similar to assuming that the rate of return for the project under consideration is 3.1 percent. But estimating an IRR for any planned project, instead of just using OMB's discount rate, amounts to exploring alternative discount rates for financial investments that can potentially yield higher than the 3.1 percent monetary returns.

Mathematically, IRR is estimated by setting the present value of net benefits (or NPV) equal to zero. Using Eq. 3, for instance, this becomes:

$$NPV = 0 = \sum_{t=0}^{n} \frac{NB_t}{(1+r)^t} \quad \text{or} \quad NPV = 0 = \frac{NB_0}{(1+r)^0} + \frac{NB_1}{(1+r)^1} + \frac{NB_2}{(1+r)^2} + ... + \frac{NB_n}{(1+r)^n}$$

This means, given that we have the estimated benefits and costs for each year of the analysis period $(t = 0, 1, 2, ..., n)$, and that $NPV = 0$, we are bound to solving for the value of the discount rate (r), which will eventually be reported as the IRR. However, considering the complexity of this formula, solving for r (i.e., calculating the IRR) using long-hand calculation is a challenging and very cumbersome task because there is no standard or systematic way of doing it. Two commonly used approaches are identifying the discount rate that maximizes the monetary returns $(r\ *)$ by trial-and-error (or iterative) method or using software developed for this purpose.

While sponsors of BCA can use a software of their choice for the case at hand, below is a brief description of the step-by-step approach for calculating the IRR using a trial-and-error (or iterative) method.[103]

- Given the NPV equation, the goal is identifying the value of r^* for which $NPV = 0$.
- Start with an arbitrary value of r, plug it in the NPV equation, and calculate the NPV.
- Depending on the value of NPV you obtained, increase or decrease the arbitrary value of r and redo the NPV calculation.

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[103] For more details, see Sambhar et al. (1992)

- Repeat this process until you get the value of r^* at which NPV becomes zero.
- Note that:
  - It is possible to obtain more than one r^* at which $NPV = 0$. This occurs when the sign of the stream of net benefits shown in the numerator of the NPV equation (i.e., NB_0, NB_1, NB_2, …, NB_n) changes more than one time (from negative to positive, or vice versa).
  - When multiple values of r^* exist, selecting the one that provides the highest monetary returns becomes arbitrary. This prompts undertaking other interactive methods not discussed here.
  - When the sign of the stream of NBs change only once during the entire analysis period, then there will be a unique (single) value of r^* that yields the highest monetary returns to the financial investments of a planned project.
  - It is worth mentioning that the stream of NBs could be negative for consecutive years and then become positive for the remaining years of the analysis period. In such a case, the sign of the steam of NBs is said to have changed only once, from negative to positive, resulting in a single value of r^*. The same holds true when the sign changes from positive to negative only once. But if the sign changes from negative to positive, or vice versa, more than once, then there would potentially be multiple values of r^*.

Appendix B-7. Costs, parameters and statistical values from other agencies

(a) Value of Reduced Fatalities and Injuries

Table A-1: Value of Reduced Fatalities and Injuries

Recommended Monetized Value(s)

KABCO Level	Monetized Value (2020 $)
O – No Injury	$3,900
C – Possible Injury	$77,200
B – Non-incapacitating	$151,100
A – Incapacitating	$554,800
K – Killed	$11,600,000
U – Injured (Severity Unknown)	$210,300
# Accidents Reported (Unknown if Injured)	$159,800

Crash Type	Monetized Value (2020 $)
Injury Crash[1]	$302,600
Fatal Crash[1]	$12,837,400

1) Monetization values for injury crashes and fatal crashes are based on an estimate of approximately 1.44 injuries per injury crash and 1.09 fatalities per fatal crash, based on an average of the most recent five years of data in NHTSA's National Crash Statistics. The fatal crash value is further adjusted for the average number of injuries per fatal crash.

References and Notes

Treatment of the Economic Value of Preventing Fatalities and Injuries in Preparing Economic Analyses (2021)
https://www.transportation.gov/office-policy/transportation-policy/revised-departmental-guidance-on-valuation-of-a-statistical-life-in-economic-analysis

Note: The KABCO level values shown result from multiplying the KABCO-level accident's associated MAIS-level probabilities by the recommended unit Value of Injuries for each MAIS level, and then summing the products. Accident data may not be presented on an annual basis when it is provided to applicants (i.e. an available report requested in Fall 2011 may record total accidents from 2005-2010). For the purposes of the BCA, is important to annualize data when possible. For MAIS-based unit values, please see the VSL guidance linked above.

Table A-1 depicts the value of Reduced Fatalities and Injuries.
Source: U.S. DOT (2022, p.33)

(b) Vehicle Operating Costs

Table A-5: Vehicle Operating Costs

Recommended Monetized Value(s)

Vehicle Type	Recommended Value per Mile (2020 $)
Light Duty Vehicles[1]	$0.45
Commercial Trucks[2]	$0.94

1) Based on an average light duty vehicle and includes operating costs such as gasoline, maintenance, tires, and depreciation (assuming an average of 15,000 miles driven per year). The value omits other ownership costs that are mostly fixed or transfers (insurance, license, registration, taxes, and financing charges).

2) Value includes fuel costs, truck/trailer lease or purchase payments, repair and maintenance, truck insurance premiums, permits and licenses, and tires. The value omits tolls (which are transfers), and driver wages and benefits (which are already included in the value of travel time savings).

References and Notes

American Automobile Association, Your Driving Costs – 2020 Edition (2020)
https://newsroom.aaa.com/wp-content/uploads/2020/12/2020-Your-Driving-Costs-Brochure-Interactive-FINAL-12-9-20.pdf

American Transportation Research Institute, An Analysis of the Operational Costs of Trucking: 2020 Update
https://truckingresearch.org/wp-content/uploads/2020/11/ATRI-Operational-Costs-of-Trucking-2020.pdf

Inflated to 2020 dollars using the GDP deflator.

Table A-5 depicts the recommended monetized values of vehicle operating costs. Source: U.S. DOT (2022, p.37)

(c) Value of Travel Time Savings

Table A-3: Value of Travel Time Savings

Recommended Monetized Value(s)		References and Notes
Recommended Hourly Values of Travel Time Savings (2020 $ per person-hour)		*Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis (2016)* https://www.transportation.gov/office-policy/transportation-policy/revised-departmental-guidance-valuation-travel-time-economic
Category	**Hourly Value**	
General Travel Time		
Personal[1]	$16.20	
Business[2]	$29.40	
All Purposes[3]	$17.80	
Walking, Cycling, Waiting, Standing, and Transfer Time[4]	$32.40	
Commercial Vehicle Operators[5]		
Truck Drivers	$32.00	
Bus Drivers	$33.60	
Transit Rail Operators	$50.70	
Locomotive Engineers	$52.50	

1) Values for personal travel based on local travel values as described in USDOT's Value of Travel Time guidance. Where applicants also have specific information on the mix of local versus long-distance intercity travel (i.e., trips over 50 miles in length) on a facility, then the local travel values of time may be blended with the long-distance intercity personal travel value of $22.70 per hour.

2) Weighted average based on a typical distribution of local travel by surface modes (88.2% personal, 11.8% business). Applicants should apply their own distribution of business versus personal travel where such information is available.

3) Note that business travel does not include commuting travel, which should be valued at the personal travel rate. Travel on high-speed rail service that would be competitive with air travel should be valued at $43.20 per hour for personal travel and $73.20 for business travel.

4) Should be applied only when actions affect those elements of travel time.

5) Includes only the value of time for the operator, not passengers or freight.

Table A-3 depicts the recommended monetized value of travel time savings. Source: U.S. DOT (2022, p.36)

(d) The Value of Statistical Life

Table B.1 in U.S. EPA (2010, p. B-2) contains the central Value of Statistical Life (VSL) estimates that form the basis for EPA's current central VSL estimate. Based on the values obtained from the studies listed in the table, EPA estimated that the mean (i.e., average) VSL is $7.4 million (in 2006 dollars) with a standard deviation of $4.7 million.

To convert the $7.4 million VSL (in 2006 dollars) to 2019, 2020, 2021, 2022 or 2023 dollars, we multiply it by the Indices calculated using the GDP price deflators for the respective years (see Columns 4, 5, 6, 7 and 8 in Appendix B-3).

Estimates	EPA Estimation, 2006 dollars	2019 dollars (Index: 1.2368)	2020 dollars (Index: 1.2532)	2021 dollars (Index: 1.3105)	2022 dollars (Index: 1.4039)	2023 dollars (Index: 1.4544)
VSL: Average (in million)	$7.40	$9.15	$9.27	$9.70	$10.39	$10.76
VSL: Standard deviation (in million)	$4.70	$5.81	$5.89	$6.16	$6.60	$6.84

Table B.1 - Value of Statistical Life Estimates (mean values in millions of 2006 dollars)

Study	Method	Value of Statistical Life
Kniesner and Leeth (1991 - US)	Labor Market	$0.85
Smith and Gilbert (1984)	Labor Market	$0.97
Dillingham (1985)	Labor Market	$1.34
Butler (1983)	Labor Market	$1.58
Miller and Guria (1991)	Contingent Valuation	$1.82
Moore and Viscusi (1988)	Labor Market	$3.64
Viscusi, Magat, and Huber (1991)	Contingent Valuation	$4.01
Marin and Psacharopoulos (1982)	Labor Market	$4.13
Gegax et al. (1985)	Contingent Valuation	$4.86
Kniesner and Leeth (1991 - Australia)	Labor Market	$4.86
Gerking, de Haan, and Schulze (1988)	Contingent Valuation	$4.98
Cousineau, Lecroix, and Girard (1988)	Labor Market	$5.34
Jones-Lee (1989)	Contingent Valuation	$5.59
Dillingham (1985)	Labor Market	$5.71
Viscusi (1978)	Labor Market	$6.07
R.S. Smith (1976)	Labor Market	$6.80
V.K. Smith (1983)	Labor Market	$6.92
Olson (1981)	Labor Market	$7.65
Viscusi (1981)	Labor Market	$9.60
R.S. Smith (1974)	Labor Market	$10.57
Moore and Viscusi (1988)	Labor Market	$10.69
Kniesner and Leeth (1991 - Japan)	Labor Market	$11.18
Herzog and Schlottman (1987)	Labor Market	$13.36
Leigh and Folsom (1984)	Labor Market	$14.21
Leigh (1987)	Labor Market	$15.31
Garen (1988)	Labor Market	$19.80

Derived from U.S. EPA (1997a) and Viscusi (1992). Updated to 2006$ with GDP deflator.

Table B.1 in U.S. EPA (2010, p. B-2) contains the central Value of Statistical Life (VSL) estimates that form the basis for EPA's current central VSL estimate.
Source: [U.S. EPA](#) (2010, p. B-2)

(e) Damage Costs for Emissions per Metric Ton

Table A-6: Damage Costs for Emissions per Metric Ton*

Recommended Monetized Value(s)

Emission Type	NO_X	SO_X	$PM_{2.5}$**	CO_2
2021	$15,600	$41,500	$748,600	$52
2022	$15,800	$42,300	$761,600	$53
2023	$16,000	$43,100	$774,700	$54
2024	$16,200	$44,000	$788,100	$55
2025	$16,500	$44,900	$801,700	$56
2026	$16,800	$45,700	$814,500	$57
2027	$17,100	$46,500	$827,400	$58
2028	$17,400	$47,300	$840,600	$60
2029	$17,700	$48,200	$854,000	$61
2030	$18,100	$49,100	$867,600	$62
2031	$18,100	$49,100	$867,600	$63
2032	$18,100	$49,100	$867,600	$64
2033	$18,100	$49,100	$867,600	$65
2034	$18,100	$49,100	$867,600	$66
2035	$18,100	$49,100	$867,600	$67
2036	$18,100	$49,100	$867,600	$69
2037	$18,100	$49,100	$867,600	$70
2038	$18,100	$49,100	$867,600	$71
2039	$18,100	$49,100	$867,600	$72
2040	$18,100	$49,100	$867,600	$73
2041	$18,100	$49,100	$867,600	$74
2042	$18,100	$49,100	$867,600	$75
2043	$18,100	$49,100	$867,600	$77
2044	$18,100	$49,100	$867,600	$78
2045	$18,100	$49,100	$867,600	$79
2046	$18,100	$49,100	$867,600	$80
2047	$18,100	$49,100	$867,600	$81
2048	$18,100	$49,100	$867,600	$82
2049	$18,100	$49,100	$867,600	$83
2050	$18,100	$49,100	$867,600	$85

*Applicants should carefully note whether their emissions data is reported in short tons or metric tons. A metric ton is equal to 1.1015 short tons.
**Applicants should be careful to not apply the $PM_{2.5}$ value to estimates of total emissions of PM_{10}.

References and Notes

Technical Support Document: Estimating the Benefit per Ton of Reducing PM2.5 Precursors from 17 Sectors (February 2018)"
https://www.epa.gov/sites/default/files/2018-02/documents/sourceapportionmentbpttsd_2018.pdf

NO_X, SO_X, and $PM_{2.5}$ values are inflated from 2015 to 2020 dollars using the GDP deflator.

Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990 (February 2021)
https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf

Note: Fuel saved (gasoline, diesel, natural gas, etc.) can be converted into metric tons of emissions using EPA guidelines available at https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references

Note: The recommended values for reducing CO_2 emissions reported in Table A-6 represent the values of future economic damages that can be avoided by reducing emissions in each future year by one metric ton. After using per-ton values to estimate the total value of reducing CO2 emissions in any *future year*, the result must be further discounted to its present value as of the analysis year used in the BCA, also using a **3 percent** discount rate.

Table A-6 lists the Damage Costs for Emissions per metric ton.
Source: [U.S. DOT](#) (2022, p.38)

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