A GUIDE for REVIEWING ENVIRONMENTAL POLICY STUDIES

A Handbook for the California Environmental Protection Agency

Steven J. Moss, M.Cubed

Richard J. McCann, M.Cubed

Marvin Feldman, Resource Decisions

California Environmental
Protection Agency
Sacramento, California 95814

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HOW TO USE THIS HANDBOOK

The primary purpose of this handbook is to assist California Environmental Protection Agency (Cal/EPA) staff to fully understand the analytical reports that are presented to them by others. This handbook should help the reader "unpack" analytical reports — including identifying the underlying methodology being employed; the measurement techniques being used; and the key assumptions upon which the report findings are based, among other things — so that the information contained in these reports can be appropriately used to assist in environmental decision making. In addition, although not its primary purpose, the handbook may also be used to facilitate the development of analytical studies focusing on environmental issues.

Environmental decision makers consume substantial amounts of information presented to them by various interested parties on particular issues. While a substantial literature details how to conduct analyses for these purposes, little written guidance exists on how to critique analytical work once it is completed. This is especially true for individuals who are not technically trained. This handbook is intended to close this gap by providing environmental agency staff with a reference guide to analytical decision making approaches. In this respect, it is important to note that the handbook is meant to be descriptive rather than prescriptive. That is, the handbook is not meant to mandate the use of particular economic assumptions or even the use of economic analytical techniques at all. Instead, its intended use is to improve Cal/EPA's understanding of the implications of the analytical choices made as part of an analysis, so that the basis for analytical findings can be well understood and critiqued.

Because the handbook's intended use is as a tool to *critique* analytical reports, it tends to focus on the shortcomings of various analytical methods. It is important to note that, while all analytic methods have both strengths and weaknesses, if employed correctly they can help policy makers make better decisions. Likewise, decisions are being made in any event—the search for the perfect analytic technique should not be the enemy of the better. Finally, to a great degree many of the techniques examined in this handbook are already implicitly used by Cal/EPA staff. In this sense, the handbook simply makes the characteristics of these methods explicit, so that their use can be improved.

This handbook is not intended to be read linearly, as with a traditional report. Instead, its purpose is to provide Cal/EPA staff and others with a resource with which to review reports and analytic material. In this vein, the handbook has been organized to provide accessible explanations of analytic terms and concepts. The reader is encouraged to make use of the handbook's table of contents, index, and glossary, and to flip back and forth between sections so as to locate discussions which are of immediate use. *In particular, readers may be especially interested in starting with Chapter Three—which provides a checklist of key steps to be taken to unpack analytical reports—and employing this chapter as a basis for handbook use.*

This handbook is divided into eight chapters, as follows:

1. Chapter One discusses the rationale for publishing this handbook and the use of analytical tools in policy analysis.
2. Chapter Two describes the broad issues with which policy analysts are concerned, including efficiency, equity and risk. This chapter provides a context for the analytical techniques discussed in the ensuing chapters.
3. Chapter Three describes the key features of analytic decision making techniques and provides a stepwise guide to unpacking analytic reports.
4. Chapter Four details the key market and nonmarket variables to be measured in analytic reports and provides an overview and description of various measurement techniques.
5. Chapter Five describes the primary analytic methods used to examine environmental policies. These techniques rely on the measurement methods described in Chapter Four, combined with the stepwise framework discussed in Chapter Three, to develop systematic environmental analyses.
6. Chapter Six defines key analytic terms. These terms are highlighted in **bold** in the text of the first five chapters the first time they are mentioned in a section and highlighted selectively in Chapter Six. Key term definitions are directed at the general sense of the word rather than at all its possible variations (e.g., "theory" instead of "theoretical").
7. Chapter Seven lists commonly used analytic resources, such as reference books, analytic articles and data sources.
8. Chapter Eight presents the report index.

Textboxes are used throughout the handbook to provide specific examples or to further explore topics of interest. In general, the subject of each textbox is indicated within the text. However, the reader is encouraged to browse the textboxes to garner additional information on analytic techniques.

1 INTRODUCTION TO ANALYTIC DECISION MAKING

Increasingly, policy makers are faced with environmental challenges with significant **economic** and environmental trade-offs. The stakes — real or perceived — can be high. For example, various analyses of global climate change have predicted an apocalyptic outcome if nothing is done to reduce the risk of global warming; and the same outcome if policy makers impose the measures required to effectively address the potential problem. Divergent concerns over the dramatic implications of environmental degradation and the economic consequences of environmental regulations are not limited to global environmental issues. While the federal Clean Air Act Amendments (CAAA) identified Southern California as having the worst air quality in the nation — with concomitant health and environmental implications — a growing number of public and private sector organizations have pointed to air quality regulations as contributing to the ongoing slump in the California economy.

While the implications of today's environmental issues are large, the threats associated with them often cannot be perceived with the naked eye. The Department of Pesticide Regulation (DPR), along with other state and federal agencies, protects Californians against pesticide contamination on fruits and vegetables at levels that cannot be detected without sophisticated instruments. The U.S. Environmental Protection Agency (U.S. EPA) and regional air quality management districts issue costly regulations to protect the world's citizens against depletion of an invisible ozone layer.

Although there is substantial scientific evidence indicating that these regulations are essential to protecting environmental and human health, without educating ourselves on each one of these issues we must take it on faith that the **costs** associated with environmental protection result in worthwhile benefits. To a larger extent than ever, the political **sustainability** of environmental policies resides in the public's faith that the **government** can accurately assess the environmental risks and costs associated with addressing them.

As environmental challenges become more complex, the need for effective methods to develop sustainable policies grows. Increasingly, the public and

In many cases, the use of economic analysis is required by state and federal laws. For example, a growing number of state statutes prescribe the use of economic analysis or at least require that economic impacts be considered as part of environmental protection policy decisions.

private sectors are turning to advanced analytical methods to sort out the benefits and costs of a particular environmental policy. However, while these analyses frequently result in the development of valuable information, only those individuals with training in sophisticated aspects of policy analysis may be able to translate these data into understandable knowledge. Further, because of their apparent inaccessibility, technical analyses are frequently distrusted by constituent communities. As a result, while there is more information available today about how humans' footprints in the sand affect soil conditions at the beach than any other time in recorded history, much of this information acts to obscure, rather than to enlighten, critical environmental issues. Society may have a greater abundance of information but less wisdom.

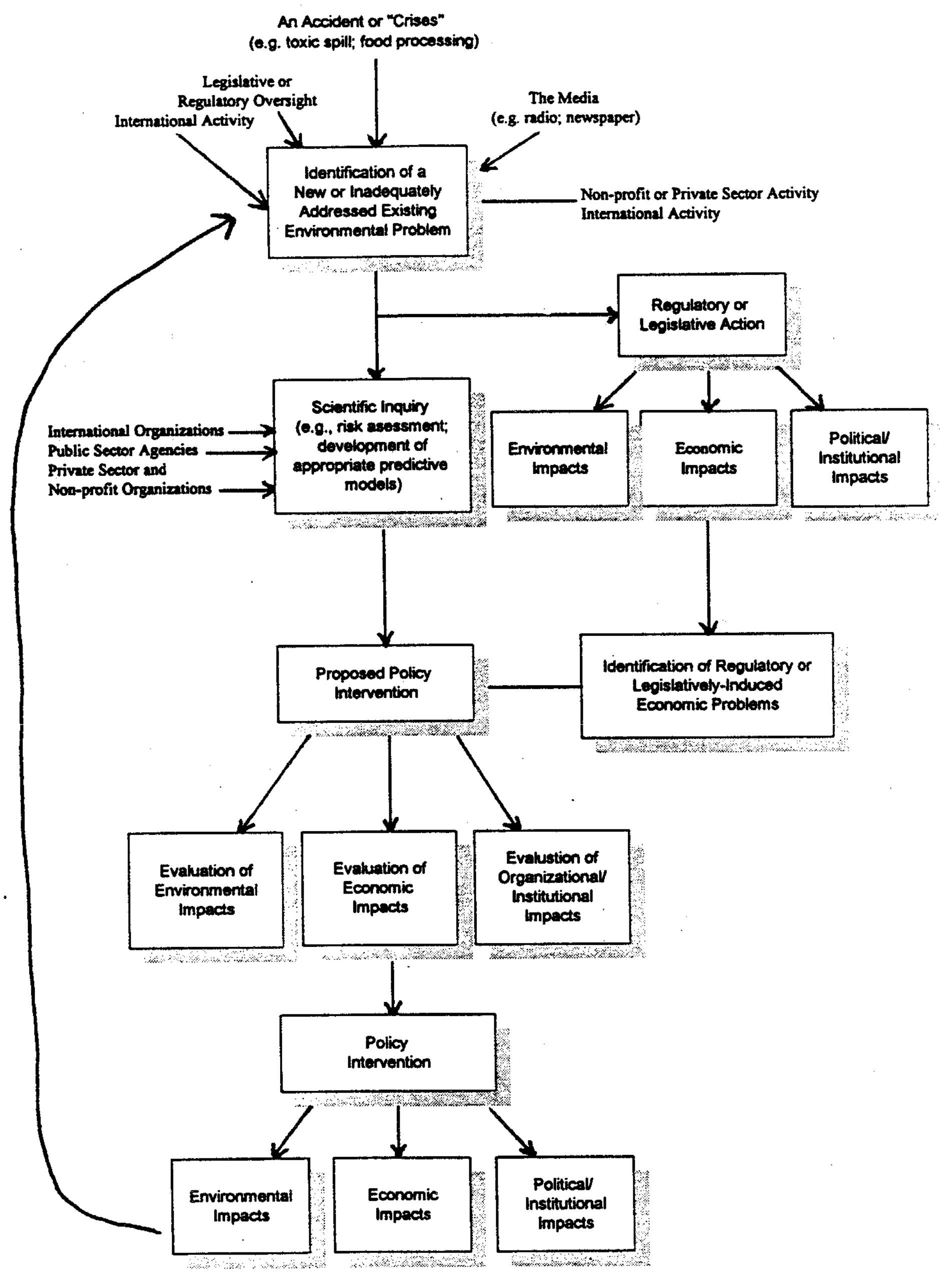
Given this policy making setting there is a critical need to increase the analytical sophistication of civil servants and others involved in policy debates. Policy makers — and to the extent possible, the public-at-large — must be able to effectively assess studies using various analytical techniques, dissect them, and understand what drives their conclusions. Through a better understanding of the strengths and weaknesses of analytical methods — and their associated findings — **decision makers** and interested parties will have an enhanced capability to use these techniques in policy debates. The result will be more effective — and more politically acceptable — environmental policies.

1.1 POLICY ANALYSES' ROLE IN ENVIRONMENTAL DECISION MAKING

Governmental **decision making** is almost always analytic in a broad sense. Information related to existing or possible future conditions is generally evaluated before a policy decision is made. Judgments are developed concerning what constitutes better and worse outcomes. **Constraints** and limitations on **options** or acceptable outcomes are weighed. Reports are analyzed. And somehow, whether by formal method or informal process, a decision is fashioned. Figure One displays one model of the process through which policy decisions are developed.

Informal decision making has worked, often very well, long before decision making emerged as a science. However, as decisions have become more complex and controversial, **ad hoc** approaches have become less likely to result in satisfactory outcomes. This is especially true in the environmental decision

Figure One
The Policy Process



WHAT ARE FORMAL DECISION MAKING METHODS?

A number of different terms are used in this handbook to refer to analytic decision making techniques. Although these words are used interchangeably, they each have a distinct meaning, as follows:

- ***Formal analysis*** *refers broadly to any analytic method — based on the scientific or social disciplines — that follows a logical line of reasoning and results in replicable findings.*
- ***Analytic decision making techniques*** *refers to any structured means of organizing various pieces of knowledge into a decision process. These techniques rely on a range of useful disciplines, including* ***economics****, sociology, political science, psychology, and philosophy.*
- ***Formal policy analysis*** *likewise relies on a number of disciplines, but is principally based on economics and political science. Policy analysis differs from analytic decision making only in that it tends to focus exclusively on solving public problems.*
- ***Economics*** *is concerned with predicting human behavior as it relates to satisfying wants and needs with limited resources, and applying this insight to a broad range of issues. Economics is particularly concerned with how scarce resources are allocated. Economics has become a primary discipline in public policy analysis because of its ability to provide decision makers with a framework from which to achieve public goals through more* ***efficient*** *mechanisms.*

Economics is the principal tool used in policy analysis. As a result, it is important to note that many non-economists erroneously view economics as exclusively focusing on issues of economic impact. That is, there is a general belief that the term "considering economics" refers only to weighing the impacts on economic indicators -- ***income****, employment, and growth -- of environmental policies. Although economic impact assessment and estimates of* ***macroeconomic*** *changes are an important aspect of economic analysis, resource economics is equally concerned with issues of efficiency and trade-offs. In other words, economic techniques can be used as a part of comprehensive investigation into the implications of environmental policies.*

making arena, where complex physical and environmental systems abound, and where difficult trade-offs must often be made. As a result, informal decision making methods are increasingly giving way to more formalized techniques. Formal decision making approaches can be used to help analyze complex problems, focus policy debate on key concerns, and contribute to consensus-building among diverse parties (see textbox above for definitions of formal decision making methods).

Historically, economics and associated formal analytical techniques have played only a limited role in environmental policy decision making. As indicated in Figure One, as often as not some specific incident — a toxic spill, the release of a report, discovery of an environmental "crisis," for example, landfill shortages — prompts or renews legislative or regulatory interest in an environmental problem. This interest can initiate legislative or regulatory action even without substantial scientific or economic evaluation. Alternatively, further scientific inquiry may be prompted by the incident or discovery, and this inquiry might in turn act to mold the ultimate environmental policy (e.g., policies developed to address ozone depletion were derived from studies conducted over a ten-year period). Only infrequently, though increasingly, are state or local environmental policies subjected to serious economic review. Even rarer are studies of the proposed policies' potential institutional impacts (e.g., how the policy may affect the way public and private sector organizations behave; the interaction between local, state, federal and international policies).

Analytic techniques are increasingly used in complex and important environmental policy debates. Sometimes analyses of the same policy come up with different conclusions. For example, economic analyses of the South Coast Air Quality Management District's air quality permit trading program—known as RECLAIM—resulted in widely different estimates of future permit prices. However, even with their differences, a close examination of the contents of analytic reports enables decision makers to make better decisions more confidently.

The technical parts of this handbook focus on understanding the use of formal policy analysis methods. The guidebook does not examine issues related to the political, scientific or **technological** basis for environmental policies. However, these issues are of keen importance to environmental decision makers and merit separate attention (see textboxes on pages that follow). For example, while a large proportion of environmental policies are based on scientific methods of **risk assessment**, there is a great deal of controversy over the appropriate methods to measure, and effectively communicate, the risks associated with environmental hazards. For instance, how to best determine whether an environmental agent poses risks to humans of one-in-a-million, one-in-a-billion, or "no risk" is an area of scientific debate. In a similar vein, scientists continue to disagree about whether or not human-induced emissions of **greenhouse** gases (including carbon dioxide, methane, oxides of nitrogen, and chlorofluorocarbons) are likely to engender global temperature increases of up to nine degrees Celsius. As with economics, policy making can be improved through a better understanding of the language and principles of environmental science.

Formal policy analysis interacts with scientific inquiry in at least three important ways:

- First, **policy analysis can help direct scientific agendas**. Policy makers rely on formal analytical methods to allocate scarce public resources among the natural sciences. When "policy" is dropped from scientific analyses oriented towards public programs, the resulting work may have only limited value. For example, despite a half-billion dollars of funding over a ten-year period, the National Acid Precipitation Assessment Program has had very little impact on federal acid rain policy. A later review of the program suggested that this was the result of a bifurcation of the research into individual scientific disciplines, with little attention to what information was needed by policy makers, and how this information would ultimately be employed.

President Harry Truman was known for "never seeing a decision he didn't like." Regardless of whether or not analytical methods are used, environmental policy decisions must be made. The techniques contained in this handbook can assist policy makers in making explicit, systematic choices that provide greater environmental protection at lower costs.

- Second, **formal analytic techniques can be used to measure the trade-offs between two scientifically-based environmental concerns**. For example, while scientific methods associate a cancer risk with the use of agricultural chemicals, science also indicates that through the use of agricultural chemicals a greater abundance of fresh fruits and vegetables are available to Americans, and that the consumption of fresh fruits and vegetables may act to reduce cancer risks. Formal analytical techniques can assist decision makers in achieving the appropriate balance between these two competing concerns.

- Third, **analytic methods can be used to determine the economic implications of existing science-based environmental policies**. For example, through the use of policy analysis regulators can better identify what standards provide environmental protection at the least-cost.

Beyond these limited areas, this guidebook essentially focuses on analytical techniques that are employed *after* the scientific basis for an environmental policy has been established.

1.2 WHAT ARE ANALYTIC DECISION METHODS?

Some individuals — particularly those that believe natural resource protection should be policy makers' first priority — are critical of the use of economics in environmental decision making. The use of economic analysis is limited *by statute* for some environmental problems. For example, application of the Endangered Species Act is partially based on protecting endangered species even if the resulting economic impacts on humans may be substantial. While there are legitimate reasons to restrict the use of formal analytic techniques in environmental decision making, economics and other related disciplines offer powerful analytical tools to environmental policy makers.

ASTROLOGY, BIOLOGY AND ECONOMICS

Centuries ago the future was predicted using a variety of methods, including reading goats' entrails, deciphering the patterns of stars in the night sky, or rolling dice. Even today many people still believe that the lines on a palm or the date of birth can foretell the events in a person's life. While in recent times some of these methods have been scientifically shown to have a ring of truth — animal behavior may indeed predict changes in weather or geological conditions — policy makers are reluctant to place their trust in them.

Instead, decision makers now turn to the physical and social sciences to help them predict the future. Both of these disciplines are essentially based on the same principle: physical, biological, and economic behavior follows identifiable patterns that tend to repeat themselves. If the causes of a given outcome can be determined — that is, the relationship between various factors and the resulting pattern — then whether or not, and sometimes when, it will happen in the future can be predicted. For example, chlorofluorocarbons (CFC) emissions into the atmosphere create a chemical reaction which, in turn, eats away at the ozone layer. While the ozone layer tends to repair itself, as long as CFCs are emitted at a rate faster than the ozone can be regenerated, the layer will degenerate. From this knowledge scientists induce that, if CFC emissions are dramatically reduced or eliminated, the ozone layer will repair itself to approximately its pre-CFC level, all else being equal.

***Economics** applies **statistical** techniques to analyze patterns of behavior within social and economic communities. Statistics is the science of generalizing from observed phenomena. Statistical techniques rely on the fact that a large number of processes follow predictable patterns. For example, rainfall tends to follow a **normal** — bellshaped — **distribution** around a mean value. Accidents, on the other hand, frequently take the form of a skewed **Poisson** distribution. Likewise, economists observe that as prices for consumer goods rise, people tend to buy fewer goods, all other factors held constant. Based on this empirical observation economists predict that when prices rise, consumption will decline. Through careful examination of such patterns, economists have developed general theories of human behavior that serve as models from which to predict future economic and social activity.*

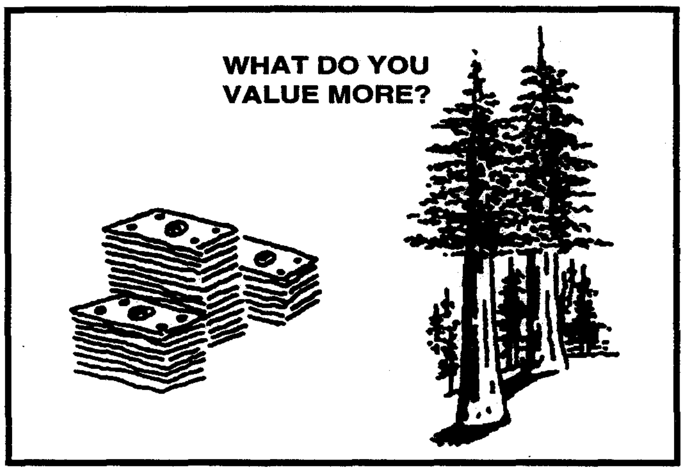
Key strengths of analytical decision methods include the following:

- **Analytic decision methods enable decision makers to systematically use complex information.** The purpose of decision-analytic methods, such as **benefit-cost** or **comparative-risk analysis**, is to organize information in an understandable and accessible form. Without these methods decision makers would have difficulty synthesizing seemingly **random** bits of information.
- **Formal methods enable decision makers to choose the most cost-effective method of achieving an environmental goal.** There is generally more than one path to reach an environmental goal. Economic methods can be used to choose the least-cost policy approach.
- **Economic-based methods can help decision makers understand the implications of proposed environmental policies.** Economic issues — such as employment, prices, and long-term income security — are among the top concerns of Californians. And to a large extent the availability of economic wealth enables the United States to provide substantial environmental protection — "wealth makes health." As a result, *the economic implications of environmental policies are of keen interest to the public.* An example of this is the intense and very public debates over protecting the Northern Spotted Owl or the adoption of air pollution programs in Southern California.

1.3 CAN *ECONOMICS* REALLY PREDICT THE FUTURE?

While **economics** can be a powerful tool in predicting social and economic behavior, economic-based analytical techniques suffer from a number of limitations. Most importantly, economic analysis begins with a status quo **baseline**. That is, *the existing characteristics of the economic system being examined form the baseline from which changes are estimated.* As a result, economic analysis can appear to emphasize the validity of current economic relationships and stress the negative implications of any changes to that system. For example, an analysis of employment and income losses associated with protecting an old-growth forest may result in estimates of significant reductions in timber-related employment without examining the economic conditions — including public-sector **subsidies** — that gave rise to the current state of the timber industry in the first place. Likewise, the employment-inducing implications of an environmental regulation are often overlooked in economic analyses. To this extent, it is important to pay careful attention to treat concerns about **efficiency** distinctly from concerns about **macroeconomic** impacts.

Correspondingly, the ability to predict future patterns to a certain extent is predicated on the continual repetition of past patterns. That is, standard economic analysis alone cannot typically forecast dramatic breaks with past patterns which result from technological, political, or social changes. For example, economists did not predict the rapid petroleum price increases of the 1970s because these increases were the result of the emergence of a new pattern (i.e., the development and efficacy of the Organization of Petroleum Exporting Countries or OPEC, as well as other political and economic trends). However, many economists did predict the fall of petroleum prices in the early-1980s. These economists based their predictions on past patterns of **cartels** — as well as the general pattern of declining **demand** in the face of increasing **prices** — which indicated that such cohesive behavior tends to degrade over time in response to other economic and political pressures.



Other general limitations of economic analysis include the following:

- **Dominant assumptions importantly influence the outcomes associated with formal policy analysis.** All analyses are driven by a number of key assumptions. These assumptions range from the grand — the perfect operation of markets — to the sublime — the future will value environmental **attributes** more than the past. ***A primary goal of this handbook is to assist the reader in identifying and weighing the merits of the key assumptions embodied in individual analyses.***
- **A tendency to "monetize" everything**. Economic techniques by their nature tend to result in monetary-based estimates of the changes resulting from environmental policies. This monetization is valuable in that it acts to standardize changes in a way which allows for comparisons between otherwise difficult-to-compare attributes (e.g., how to compare the worth of a life to the worth of a forest). However, to some, monetizing environmental

attributes reduces the poignancy — and challenges the philosophical importance — of the problem being addressed. For example, what is more important, the "**existence**" and "**bequest**" **value** associated with 350 million acres of old-growth redwood forest or $1 billion worth of timber and recreational benefits? Because the existence value of a resource does not have a measurable market price, other methods of weighing environmental changes have been developed. These techniques try to make consistent efforts to explicitly identify important environmental benefits which are not adequately reflected in prices.

- **An imbalance between the ability to estimate the costs and benefits associated with environmental policies**. Economic techniques tend to be quite good at estimating the *costs* — in terms of person hours, capital investments, employment loss and the like — associated with environmental policies that change the status quo. However, these techniques are less able to estimate the *value of the benefits* — in terms of reductions in polluting air emissions, protected wildlife habitat, and impetus for new technological development — associated with these policies. As a result, economic analysis can encourage decision makers to focus more attention on the costs of environmental regulations than the benefits.
- **Economics relies on the "marketplace" rather than polling booths to arbitrate public decisions.** Individuals participate in the marketplace by trading dollars for goods and services. People can vote in the marketplace with multiple dollar amounts rather than on a one person/one vote basis. Because peoples' ability to vote in the marketplace is limited by individual wealth, the wealthy can have more influence on economic outcomes than the poor.

In no way do these limitations represent "fatal flaws" in economic analytical techniques. In all cases, economists and others are working to devise means of addressing these weaknesses. More importantly, they serve as reminders that *no* discipline can provide answers to all of policy makers' questions. It is important that decision makers draw from a variety of disciplines to develop the wisdom they need to address today's complex environmental problems.

2 WHAT IS FORMAL POLICY ANALYSIS?

The discipline of **economics,** together with other behavioral, legal, and physical disciplines, provides many of the principal tools for formal policy analysis. Policy analysis is based on a four step process:

- First, a **theory** explaining the behavior of interest is developed. A theory is essentially a credible "story" describing why events occur as they do. In general, theories, whether from economics, biology, physics or meteorology, attempt to predict how specified actions lead to certain outcomes.
- Second, base **assumptions** are made about the prevailing conditions of interest. Identifying and understanding the assumptions embedded in the theoretical framework is a necessary step to distinguish why two reports arrive at different answers. The use of assumptions addresses two needs in advancing the study of a topic:
    1. Assumptions simplify the analysis so as to make it analytically tractable and/or
    2. Assumptions fill in for missing or unattainable data.
- Third, **empirical evidence** that can be used to test the theory is identified and evaluated. Based on this evidence the original theory may be modified or even rejected.
- Fourth, a conclusion is drawn about the validity of the theory, and whether a policy derived from the theory can adequately address the identified problem.

2.1 WITH WHAT ISSUES ARE POLICY ANALYSTS CONCERNED?

Environmental policy analysis is primarily concerned with three issues:

- Evaluation of the net gains or **costs** to society as a whole from *expected* outcomes of environmental policies — this category usually is called *"efficiency analysis."* **Efficiency** analysis focuses solely on calculating societal benefits and costs, without regard to the initial distribution of **income** and **wealth**, winners and losers, or how **risks** might change as a result of a policy or program.
- Assessment of the distribution of gains and losses from an outcome across different dimensions, including social, spatial and temporal — this is usually called ***"equity analysis."***
- Estimation of the risks posed to society and various groups by **uncertainty**, and responses by individuals and organizations to avoid or mitigate these risks — this is usually called *"risk analysis."*

Economists tend to place the greatest emphasis on achieving efficient outcomes, while lawyers, for example, are predisposed to focus on issues of equity and risk-responsibility. However, only the **decision maker** or **stakeholders** can weigh the relative importance of these three elements. In addition, **economics** provides little guidance on how to weigh equity concerns as part of decision

ASSUMPTIONS: AT THE HEART OF THE MATTER

The use of different analytical assumptions frequently explains the difference between analytical findings derived from the application of like methodologies. Having a clear understanding about the key assumptions used — and the sensitivity of the results to changes in these assumptions — is a critical part of unpacking any analysis.

For example, in one analysis of the South Coast Air Quality Management District's marketable permits program, or RECLAIM, it was assumed that program implementation would reduce the cost of new pollution-control technologies by an annual rate 3 percent faster than existing trends. However, if this assumption turned out to be incorrect — and current rates of cost decreases remained unchanged — the estimated net savings from the permit program would be reduced by 10 percent.

*In another example, cost estimates for a proposed ethanol plant to be constructed in the Sacramento Valley varied widely depending on assumptions about potential **rates of return**, annual production volumes, and various input costs. In this case, the mix of assumptions chosen to develop the estimates could affect the potential economic feasibility of the plant, and affect the ultimate decision about whether or not it would be built.*

making. Even risk analysis requires some **assumptions** about individuals' preferences that many economists are uncomfortable making. Decision analysts prefer that these **normative**, or value-based, trade-offs be explicitly made by decision makers or stakeholders.

2.1.1 EFFICIENCY

Efficiency seeks to achieve the greatest net benefits in individual satisfaction — the total gains minus the total costs — from a particular policy. In other words, efficiency criteria demand that the identified goal be achieved for the least cost. For example, choosing the least wasteful way of meeting a pollution standard — or obtaining a given goal at the least-cost — is efficient. The ultimate efficiency measure — called the **Pareto criterion** — defines an efficient choice as one where everyone is at least as well-off after a chosen action as before the action is taken, and at least one individual is better off — there are no losers from the policy. Pareto optimal policies are rarely available in the real world, prompting economists to develop less restrictive definitions of efficient actions. These definitions — including the **Kaldor-Hicks criterion**, also known as the "potential compensation principle" — seek to maximize individual benefits across a number of **variables**. Unlike the Pareto criterion, under Kaldor-Hicks, while most people are made better off under a policy, some individuals may be made worse off. As long as those who are better-off can theoretically compensate those who are worse off and still come out ahead, the policy is considered to be worthwhile. This is also called Partial Pareto Efficiency (PPE). Whenever net benefits are greater than zero, PPE is satisfied. That is why economists generally approve of policies which have positive net benefits.

*Within efficiency, equity, and risk analysis, economic analysis is typically broken into two categories — **microeconomics and macroeconomics**. Microeconomics focuses on how individual firms or consumers behave. Macroeconomics asks how the activity of individual firms and consumers aggregate to affect the overall economy.*

Many types of **constraints** exist on policy choices, but for economic efficiency analysis the two most important are the **budget constraint** and the **technological or production possibilities frontier:**

- Everyone faces budget constraints of some kind. These are constraints not only on our income and wealth, but also on time and other available resources. Budget constraints act to limit available spending on a particular problem. An efficient outcome is the one which achieves the maximum satisfaction given limited resources and the necessity to trade-off among preferences.

IS ENVIRONMENTAL AND ECONOMIC CHANGE ALWAYS BAD?

People tend to resist change, but is all change bad? The natural environment is mutating all the time — species become extinct and new ones develop. Some of these changes are the result of non-human events — current ***theory*** *hypothesizes that the dinosaurs were killed off by atmospheric changes created by the earthly impact of a large space object. Other more recent changes are the result of human activity. For example, reductions in fish habitat in the Pacific Northwest are the direct result of overfishing, the construction of waterways and dams, and introduction of silt from timber harvesting.*

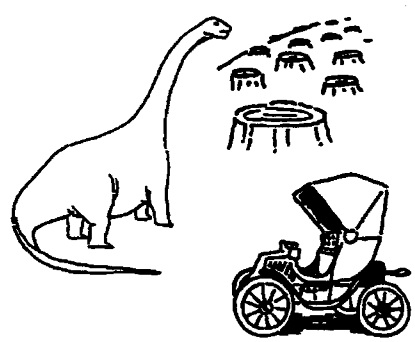
The economic environment is similarly constantly changing, generally as a result of human activity but sometimes due to changes in the natural environment. With the invention and rapid adoption of automobiles and airplanes, far fewer jobs are associated with horses and railroads in 1993 than in 1893. Earthquakes and fires in California and hurricanes in Florida have wreaked havoc on regional economies, but also created the need for new and safer buildings and induced billions of dollars worth of new economic activity in the affected areas.

Change, while frequently inducing demands for policy action, does not in itself indicate the creation of a problem to be addressed. Instead, as with ***risk****, the incidence of change initiates a two-step process:*

1. *Assessment of the implications of change; and*
2. *Development of methods to manage the change should that be deemed necessary.*

Environmental decision making likewise occurs as a continual process in which varying amounts of analytical information are used to address constantly shifting environmental, political, social, scientific, and ***economic*** *concerns. In this respect, even when an environmental policy is implemented through legislative and regulatory action, the development of additional information and new concerns can act to change the policy over time. As a result, environmental policy making is never "finished." The policy itself, once enacted, becomes part of the dynamic environment in which physical and social conditions exist. A problem may change form, policy proposals will be reformulated, and unforeseen* ***constraints*** *may materialize as part of the evaluation and implementation process. The policy process should not be seen as necessarily following a linear track, but rather as part of a loop that feeds back information to the initial step.*

SOME THINGS HAVE CHANGED



- The technological or production possibility frontier defines the possible combinations of **goods** and services given a fixed set of inputs. For example, while having a picnic on Mars might be fun, our ability to get there is quite limited. Likewise, we can't both prohibit all logging and maintain a thriving timber industry. The choice set of available policy options is similarly constrained by available **technology**.

DISCOUNTING — MORE THAN JUST RETAIL BEHAVIOR

*The theory of **discounting** addresses the **intertemporal** and potentially **intergenerational** implications of private and public investment choices. **Present-value** discounting refers to the reduction in value associated with receiving payments in the future rather than the present (i.e., we usually prefer to have something today rather than tomorrow). There are three justifications for discounting. The first is intertemporal preferences or "impatience." The second is the opportunity **cost of capital. Income** that is not spent consuming today could be invested, thereby yielding more income to consume with tomorrow. Finally, there is uncertainty associated with future payments on debt incurred in the present. Discounting is used in everyday life when, for example, individuals choose to use a credit card instead of cash.*

*As the discount rate used increases, the present value — the worth today of the entire stream of net benefits over time — of the investment declines. For example, the U.S. Office of Management and Budget (OMB) recommends the use of a **real** — inflation free — **discount rate** of 7 percent. Based on this rate, a dollar received two decades from now is worth only about a quarter today. A dollar received a half-century from now is only worth three cents. That is, we would only pay 3 cents today for a dollar to be received in fifty years. OMB's discount rate does not reflect the low **opportunity costs** of capital that existed during various historical periods, such as during the Great Depression.*

The declining values associated with discounting have a significant affect on policy decisions. High discount rates act to shrink the benefits connected with investments that payoff far in the future, while quick paybacks appear more beneficial. The use of double-digit discount rates can act to block approval of otherwise worth-while projects. For example, based on OMB's discounting guidelines the Golden Gate Bridge may have been built with a shorter lifespan as a means to reduce costs. Likewise, as environmentalists like to point out, Louisiana would never have been purchased if OMB's discounting requirements were in place. Choosing a discount rate is not without contro-versy, and this choice should be reviewed carefully as part of the decision making process.

WHEN DOES OPPORTUNITY HAVE A COST?

The concept of ***opportunity costs*** *is of critical importance to policy analysis. From an economic perspective, opportunity cost is the answer to the question: how much do I have to give up to use a resource? For example, if a house is worth $200,000, the home-owner's opportunity cost is $200,000. Opportunity costs represent the value of the best alternative use for a resource.*

Opportunity costs differ from ***accounting costs*** *in that the latter are the out-of-pocket expenses,* ***depreciation****, and historical costs that are used in bookkeeping entries. For instance, a drill press might have cost $10,000 to purchase a decade ago and it might have depreciated to a zero value today in a firm's books. However, that drill press may be working just as well today, and a new press may cost $15,000. The economic value of the old press, measured by its opportunity cost, is $15,000, adjusted for the difference between the expected remaining life of the old and new presses. However, on an accounting cost basis the old press has no value.*

2.1.2 EQUITY

Equity is concerned with how the benefits and costs generated by a policy are distributed. Distribution of benefits and costs may differ by social or economic standing, by location, or even by generation. From a political perspective, the ultimate distribution of policy outcomes may be the single most important issue, superseding even the expected total impacts as a measure of desirability. For example, one policy option might increase society's economic wealth by a billion dollars, but only the wealthiest ten percent benefit; on the other hand, a second option might generate half a billion dollars in benefits, but these are distributed to half the population. The first option may be more **efficient**, while the second may be more equitable.

Analytical methods alone do not a decision make. In addition to the use of decision analytic techniques, effective environmental policy making is dependent on public participation, rules of law, and social considerations.

While equity is concerned with who receives benefits, economic analysis also indicates that the receipt of an additional dollar has a dissimilar marginal value to different income groups. In formal terms, the **marginal utility** of income may not be constant as income and wealth increase — a family with poverty level income may value an additional dollar more than a wealthy family. In other words, a strict monetary-based comparison, as in the example above, may not be appropriate if the affected groups have substantially different income levels. Consequently, distribution to the less-well-off population, while engendering a smaller absolute monetary gain, may be preferred by society both because it benefits a particular community and because the aggregate increase in **utility** may actually be larger—ultimately the true measure of efficiency.

Equity goals can be evaluated in several ways, depending on the relationship between the relevant individuals and the expected policy results. There are two different perspectives on how to examine equity issues related to individuals, as follows:

- **Horizontal equity** states that individuals in similar situations should be treated similarly (e.g., a policy that affects rice farmers should apply to all rice growers equally). For example, the American justice system is based on the principle that "all are equal in the eyes of the court."
- **Vertical equity** states that individuals in dissimilar or unequal situations should be treated dissimilarly in an effort to make them more equal. Under vertical equity, for example, the poor receive more benefits from **government** than the wealthy. Affirmative action programs are intended to remedy perceived racial inequities through differential treatment of individuals based on race.

Vertical and horizontal equity are not mutually exclusive goals (e.g., the federal tax system increases the tax rate with rising income but taxes those in the same tax bracket at the same rate).

Two other notions of equity arise associated with policy outcomes. These are equity related to the fairness of an <u>outcome</u> (e.g., are the resulting levels of income equal?) and the fairness of the <u>process</u> (i.e., was there equality of opportunity or access for the individuals involved?). Those interested in equitable outcomes attempt to develop policies which guarantee particular results, while those concerned with equitable processes seek to provide everybody with equal opportunity (see "When is Fair "Fair"?" textbox).

WHEN IS FAIR "FAIR"?

In California's dynamic economy jobs are lost and gained all the time. For example, the state supports fewer mining jobs today than it did a decade ago, while, until the onset of the 1991 recession, construction jobs had almost doubled. Federal and state governments may want to intervene for other reasons, but the simple fact of a declining industry does not, necessarily, raise society-wide equity concerns. For example,

- *Over the last few years law firms throughout the state have been forced to reduce their staff and restrict their number of new hires as a result of declining private sector demand for legal services. Should the state government establish special programs addressing the needs of unemployed attorneys?*
- *The state's aerospace industry has been in steady decline since the late-1980s as a result of reduced federal spending on military equipment. Should public funds be spent to retrain unemployed aerospace engineers?*
- *Small metal-working firms in Southern California have been forced to either close or move out of the state partially as a result of federal, state and regional environmental rules. Should assistance be provided to these firms to encourage them to remain in business in Southern California?*
- *The 1991 recession resulted in particularly high statewide unemployment rates. Should the federal or state government extend unemployment insurance benefits beyond their typical expiration date?*

In general, policy makers become especially concerned about the equity implications when a specific policy is likely to result in the dislocation — whether through employment reductions, or elimination of housing — of a particular population. Policy makers tend to be less concerned when general economic trends act to disrupt certain populations.

Equity is measured by distributional impacts, which can be divided into three dimensions:

- **Socioeconomic** focuses on groups of individuals within society, whether economic, ethnic, racial or political.
- **Geographic** can be divided by natural, economic or political boundaries. Geographic impacts differ from socioeconomic impacts in that they (1) affect individuals in a certain locale; (2) cut across socioeconomic groups; and (3) impact other physical and biological resources as well. The consequences of geographic impacts can be similar to those found in socioeconomic analyses, but also include potential changes in land use patterns, biological inventories, ecological balance, and other issues.

- **Intergenerational and intertemporal** focus on how impacts differ across time. The fundamental trade-off being assessed in intergenerational environmental analysis is how consumption and **investment** should be valued now and in the future. For example, consumption of environmental resources today may deprive future generations of these resources. Likewise, investments in environmental amenities today requires sacrifices by the existing generation on behalf of tomorrow's generation (see "Discounting: More Than Just Retail Behavior" textbox).

Weighing distributional impacts requires applying values to the decision about who is most deserving of benefits and costs. Unlike the "efficiency" and "**maximum return at minimum risk**" standards used by financial analysts, decision analysts have not developed consistent criteria with which to value distributional impacts. While the decision making process can be used to

RISK ASSESSMENT: AN UNCERTAIN FOUNDATION

*Environmental policy analysis begins with an assessment of the threats or **risks** posed to the natural environment and public health. As a result, policy analysis is to a large degree dependent on accurate scientific findings. While we've come a long way since scientists roundly agreed that the world is flat, controversy over particular scientific methods and outcomes continues to this day.*

*Scientists weigh a number of factors when evaluating the risks associated with a pollutant or human activity. There is always some **uncertainty** about each of these factor's ability to predict the event in question. However, based on this chain of factors, scientists estimate the risks related to the pollutant or activity. Key links in this chain include the following:*

- *The **probability** that a pollutant will be released, or that harm will result from an activity.*
- *The quantity of the pollutant released or the activity level.*
- *The dispersion patterns of the pollutant or activity.*
- *The pollutant concentration or the scale of the activity relative to its surroundings.*
- *The population exposed to the pollutant or impacted by the activity.*
- *The "uptake rate" or population exposure.*
- *The dose-response relationship of the pollutant or activity to the exposed population.*

In each step, scientific uncertainty may be compounded, potentially resulting in a wide range of estimated risks. As a result, while science can offer profound and useful insights into the risks Californians face, analysts must be careful to apply scientific findings appropriately.

gather the relevant information and to construct a framework in which to assess the trade-offs inherent in distributional questions, it is up to the policy maker to reflect his or her constituents' preferences in this matter.

2.1.3 UNCERTAINTY AND RISK

Uncertainty refers to a lack of knowledge about future outcomes. Risk is the potential loss from an uncertain outcome.

Issues of **uncertainty** are important to consumers and producers, and, depending on the level of uncertainty associated with a particular economic activity, these issues can affect their decisions dramatically. Most individuals will take actions to avoid undue amounts of **risk**, and in most cases this means giving up some higher level of income or wealth to choose a more certain course. Insurance — where people and firms are willing to pay a "premium" to spread and share their risks with others — is based on this premise. Using similar principles, financial investments are arranged in "portfolios" that attempt to balance uncertainty about investments with potential returns. While the preferred choice from an "efficiency" standpoint may be to accept higher risks, consumers and managers often will turn to a more certain outcome that limits potential losses at the expense of higher returns.

Policy makers face similar types of uncertainties, particularly in environmental decisions. No policy is formulated with absolute certainty. Environmental quality, such as for air or water, can be affected by many factors other than the directly offending human activity. For example, the level of polluting air emissions can be affected by a particularly hot summer or an unexpected change in economic activity. These outside influences can alter environmental quality measures and mask the impacts of activities with which policy makers are most concerned (see "Issues of Risk Assessment and Risk Tradeoffs" textbox).

2.1.4 WHAT WE KNOW ABOUT UNCERTAINTY

Uncertainty comes in two forms. The first relates to our understanding of how various natural and human processes work. The second relates to future events and trends.

The first form of uncertainty relates to the basis on which any analysis is built. Because virtually all natural and human-constructed systems are highly complex, no single theory, modelling method, or data source can capture all of the forces that drive these systems. Even beyond **theories** themselves, uncertainty usually exists about the historic information on which the theories are constructed and tested. For example, the data col-

ISSUES OF RISK ASSESSMENTS AND RISK TRADE-OFFS

*The science of **risk assessment** focuses on determining the hazards associated with exposure to various environmental conditions. For example, one aspect of risk assessment is concerned with estimating what quantity of a particular toxic chemical it takes to induce certain types of cancers in humans. Likewise, risk assessment seeks to determine the probability that death or injury will result from using different transportation modes, including airplanes, automobiles, or rail. There are a variety of ways of assessing risk, ranging from the development of personal knowledge through experience — if I put my hand in the fire, it will hurt — to methods based on inference — if the ingestion of a particular chemical by a rat hurts the animal, it may also harm humans.*

*The art of **risk management** focuses on reducing the possibility of mortality or morbidity associated with the environmental conditions examined in risk assessment. Risk management policies include limiting the incidence of a particular chemical in the environment; requiring certain protective devices be used when engaging in a risky activity; and accepting the risk in return for the benefits derived from the action.*

Risk management practices are frequently usefully informed by economics. In many cases, risk management involves trading-off between economic, health, and environmental benefits, both on an individual and societal level. For example, while a driver is probably safer in an $80,000 Mercedes Benz than in an $8,000 Isuzu, few people are likely to mortgage the house for the Mercedes, at least not as a way of reducing the risk of harm from accidents. Likewise, driving 65 miles per hour (mph) carries a greater risk of a fatal accident than driving 55 mph, yet this well-publicized fact does not prevent many drivers from exceeding the speed limit. And while society is willing to provide every citizen with some basic amount of health care, through formal public programs or emergency assistance, the public has not yet shown a willingness to provide all individuals with the most expensive medical services available upon demand.

particular topic may not match the timeframe or spatial qualities necessary to test a theory. The reporting may be of mixed quality, especially if it is done as an adjunct to other activities, or it may not even be clear what should be measured. This **measurement error** can introduce substantial uncertainty into any analysis.

The other dimension of uncertainty is the one we consider in our own lives every day — what does the future hold for us? This type of uncertainty comes in two forms, the first arising from our inability to fully understand complex systems; and the second from the inability of governments and other organizations to be able to absolutely commit to certain policies forever due to electoral or managerial changes. Uncertainty resulting from the operations of complex systems can, in some cases, be estimated through various mathematical techniques; however, knowledge of such basic natural phenomena as weather and earthquakes remains primitive. Understanding institutional uncertainty is important in accounting for human and organizational behavior.

Uncertainty about human institutions and technological ingenuity is not easily quantified but it does color how individuals and firms respond to new policies. In one dimension of institutional uncertainty, even if one governmental agency commits to a certain strategy, another related agency can greatly affect the implementation of that policy. For instance, the California Air Resources Board (CARB) cannot set air quality standards without considering potential actions by the U.S. Environmental Protection Agency. Thus, firms choosing their own emission management strategies must consider whether the U.S. EPA might trump the CARB decision in the future. Uncertainty about the ability to rely on continuance of a government policy can create greater risks that push behavior away from what would be considered optimal. Likewise, the operations of the marketplace engender significant uncertainty about a wide range of factors, including future fuel prices and economic growth. Technological uncertainty similarly can be affected by the policy choice itself, as certain strategies can encourage or discourage new innovations.

ASSESSING EFFICIENCY, RISK AND EQUITY: WATERSHED PRESERVATION AND AIR QUALITY STANDARDS

To examine what is a relevant policy analysis process, a small-scale project — a small urban ***watershed*** *rehabilitation program — can be contrasted with a broad policy proposal — region-wide air quality standards. The former requires a substantially less extensive, but more detailed, evaluation than the latter. The impacts of changing the watershed might be measured with more accuracy due to the limited local focus and more easily understood* ***ecological*** *mechanics, but the impacts are much less widespread than from reaching the air quality goals. The economic analysis of the watershed project can be evaluated with simple analytic tools that rely on narrow cost and benefit estimates; the air quality policy analysis requires a broad multisector regional model that considers how the economic impacts weave through the economy, and that reflects the high degree of uncertainty about analytic results due to the complexity of the problem and lack of data. Based on this example, issues of efficiency, equity and risk can be examined.*

Efficiency *- Efficiency is obtained when the maximum benefits are achieved for a given cost. For the watershed, the benefits might include a restored fishery, better water quality and an enhanced riparian habitat. The costs might include construction, runoff regulation measures and land use controls. Each of these items is relatively well defined, and the value can be estimated with economic techniques and weighed by decision makers with some assurance of accuracy. For the air standards, the benefits are much broader and more difficult to estimate. For example, benefits might include improved health, better visibility, and reduced structural and crop damage. Estimating the costs of air quality standards is difficult as well, because this requires modelling the complex economic system contained in the air basin.*

Equity *- The ability to estimate the distribution of gains and losses with some accuracy depends on the scale of the problem and the reliability of the supporting data. For the watershed, local residents are the likely gainers; but they may also be losers to the extent that they either have to modify their discharges or change their building plans. Taxpayers in general may be losers to the extent that they subsidize the activities involved in the restoration. The job losses and other socioeconomic impacts are likely to be small. The air standards issue presents a number of difficulties related to measuring equity outcomes, including having sufficient data on the characteristics of affected groups; estimating the range and intensity of geographic impacts that are forecasted with imprecise airshed models; and determining how this action might change future consumption and investment patterns in the region.*

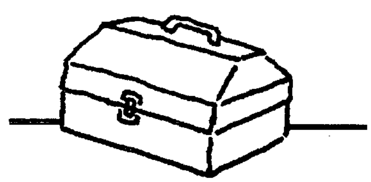
Risk *- The risk associated with any policy option is related to the existence of and response to uncertainty. For the watershed, the level of uncertainty is relatively small for the people affected by the decision. For the flora and fauna though, the risk of failing to achieve the required level of sustainable activity may be substantial if the understanding of the ecology is not sufficient. For the air standards, there is generally a trade-off in risks, between achieving an ambient standard by a certain time versus imposing significant economic hardship. Understanding the bounds on possible outcomes may be more important here than estimating an expected result, especially since almost all single-point forecasts will be wrong.*

3 WHAT IS IN OUR ANALYTICAL TOOL KIT?

This chapter provides a discussion of the key elements of analytic decision making. The chapter is divided into three primary sections. First, the key features of analytic decision making are presented. Then, a step-by-step guide to evaluating analytic decision reports is provided. Finally, a case study illustrating how to apply the approaches previously presented is discussed.

Analytic decision making techniques provide a means to assemble differing analytic components into a systematic decision process. Although analytic decision making approaches vary, they all have the following common features:

- Follow a structured and consistent approach
- Explicitly define the problem
- Explicitly define policy objectives
- Specify the range of alternatives
- Specify any constraints on alternatives
- Separate objective inputs from subjective inputs
- Are based on a bounded choice set and analytical limitations.



In addition, policy analysis seeks to measure outcomes and compare these outcomes with desired results.

3.1 KEY FEATURES OF FORMAL ANALYTIC DECISION MAKING TECHNIQUES

Analytic reports usually include the following features, which are part of well-structured analyses:

- **Follow a structured and consistent approach.** Decision making techniques rely on using a structured and consistent framework which exists independently from the specific problem or policy under consideration. This framework feature is important for several reasons. It can provide a means of integrating both descriptive inputs and goals; can be thoroughly tested and substantiated based on previous applications; and is based on sound behavioral and **economic theories**. A structured approach provides a neutral mechanism for decision making, favoring neither specific policies nor specific outcomes. Likewise, a structured approach establishes a common forum within which multiple decision makers who might disagree on policies or desirability of outcomes can integrate their concerns.
- **Explicitly define the problem**. Environmental problems are generally defined by scientific evidence that indicates potential or actual change to human health or the environment. The characteristics of the problem will dictate the type of and need for analytic information. Environmental problems exhibit a large number of different characteristics, including:
  - **Size** — is it a large problem, such as global warming, or a smaller problem, such as a toxic waste spill?
  - **Scope** — how many issues are involved and how are they interrelated (e.g., the trade-offs inherent in preserving both the winter salmon and the Delta smelt in the Sacramento River)?
  - **Speed** — is the problem slowly imposing environmental change, such as the potential for global warming, or is it happening more rapidly, such as drought-induced water shortages?
  - **Permanence** — can the impacts of the problem be reversed?
  - **Risk Level**— does the problem pose a clear and present danger or some lower risk level?

- **Explicitly define policy objectives**. Policy *goals* or *objectives*—which are based on underlying *values*—are the outcomes desired from addressing the identified problem. Goals can range from complete elimination to partial mitigation of the problem. For example, acceptable damage and risk thresholds could be established, or the economic impacts associated with the problem could be ameliorated.

The more explicit the policy objective, the more readily it can be measured. For example, saying that "this policy should be fair" provides little guidance. Alternatively, saying "this policy should minimize the redistribution of **income** away from the identified segments of the affected population" virtually defines the entire aspect of the problem. By being explicit, the analysis can clearly differentiate among the goals, the means of achieving the goals, and the quality of the supporting analyses.

Policy analysis tends to define goals in terms of "**objective functions**." An objective function is a means of measurably indicating which outcome sets are preferable to all other possible outcomes. Objective functions may include economic variables (such as **cost**), health variables (such as lives saved), environmental variables (such as habitat created) and many other possible considerations. Conflicting objectives — such as goods now versus goods later — may coexist in an objective function. But if the function is to be analytically useful, these conflicts must be specified in terms of explicit trade-offs of one objective versus another.

- **Specify the range of alternatives**. The purpose of the decision process is to enable participants to choose the best alternative. This implies that at least two distinct, feasible options be available. Often there are a large number of choices and subsets of choices possible. Other things being equal, the larger the set of options considered, the better the analysis. Eliminating or failing to consider an alternative might not only alienate some **stakeholders** but risks ignoring what might prove to be the preferred choice. However, as it is necessary to evaluate each alternative in terms of the objective function, there is a practical limit to the number of alternatives which can reasonably be considered. A practical approach to limiting the number of options is to group alternatives which have common or partially overlapping outcomes. Also, as the technical analysis progresses, it is sometimes possible to prune the list of choices to eliminate "dominated" alternatives, that is, options which perform worse than others on all considerations within the objective function.

- **Specify any constraints on alternatives. Constraints** can be "fatal flaws" which make an alternative unacceptable. Potential options may be limited — constrained — by various factors, including **technological** (is it feasible), budgetary (is it affordable), legal (is it allowable), political (is it socially acceptable), or **ecological** (is it environmentally sustainable). Legal constraints can also work the other way, acting to require that certain elements be incorporated into the policy analysis. To the extent that certain outcomes are identified as being unacceptable, it might be appropriate to terminate evaluation of the alternative which induces these outcomes. However, prudence is advisable in eliminating a potential choice because it might be the one which performs best in terms of all other considerations in the objective function.

Positive inputs reflect observations and inferences using different analytic methods — engineering, scientific, and behavioral — of what is (i.e., an objective measure of the status quo). Normative inputs refer to judgements concerning the way outcomes ought to turn out (i.e., they reflect subjective preferences). "Should" is normative; "is" or "will be" are positive.

- **Separate objective or technical (positive) inputs from valuative or subjective (normative) inputs.** Paradoxically, there is nothing "objective" about an "objective function." Indeed all of the **normative** judgments to be included in the decision process are appropriately contained in an objective function. What IS "objective" about the objective function is that it embodies the goals or objectives to be accomplished by the decision.

The **positive** or technical aspect of the analysis lies in determining the outcomes or impacts of each of the alternatives. This technical analysis should be performed by specialists in disciplines appropriate to the impacted area (e.g., economists for economic impacts, epidemiologists and meteorologists for air quality impacts, etc.). While these technical experts have the best understanding of what *might* happen, in their capacity as experts they should strive to keep their findings value free. The beauty of analytic decision making is that it permits the positive and normative aspects of a problem to be addressed by those most suited to understanding each of these aspects.

- **Bounded choice set and analytic limitations.** All of the above discussion of analytic decision making is based on the **assumption** that the problem is well defined, and that the range of alternatives is limited to a tractable number of choices. Under these circumstances the discipline imposed by the analytic process forces a clear definition of objectives, and reasonable consideration and consolidation of alternatives.

However, the analyst, and especially the consumer of the analysis, must be sensitive to analytical limitations. Key factors that can limit analytic decision making include the following:

- Analytic methods tend to specify problems and solutions in mathematical forms. As a result, qualitative differences and unmeasurable characteristics are frequently not included in analyses. It is important to be aware of what is left out of the analytic framework, and to **heuristically** consider the importance of these omitted aspects to the ultimate decision (see "Being a Sensitive Analyst" textbox).

- Analytic studies require a certain degree of simplification to assess the general implications of a policy proposal. However, by simplifying the analysis, certain costs may be intentionally or unintentionally ignored. Commonly omitted costs include the following:
  - *Adjustment costs*, which may result from accelerated shifts to new technologies, leading to premature obsolescence of existing investments.
  - *Implementation costs* of **government** agencies, including hiring new personnel, purchasing different equipment, and developing expertise in emerging issues.
  - *Compliance costs* of the regulated community and *monitoring and enforcement costs* of the regulatory agency. Neither of these cost components are well understood by analysts due to the great variety of regulatory schemes and degrees of enforcement.
  - *Transaction costs* may arise for policies in which **market** forces are being harnessed to achieve regulatory goals. For many items, individu-

HOW TO BE A SENSITIVE ANALYST

Almost all economic analysis should be subjected to ***sensitivity tests****. Sensitivity tests involve changing a model* ***parameter*** *and observing how the resulting analysis changes — how sensitive the analytical results are to a particular* ***variable****. Sensitivity tests enable analysts to examine the* ***robustness*** *of study findings given* ***uncertainty*** *about the data and the assumptions upon which the analysis relies. For example, if the analyst is unsure about critical model parameter estimates — such as* ***price elasticities*** *or rates of technological adoption — alternative analyses based on different assumptions can be developed. Sensitivity tests can act to demonstrate that an analytic result is fairly strong even in the face of different assumptions, or that an inherent risk exists in choosing a policy because the understanding of it is insufficient to accurately predict its outcome.*

Scenario analyses *are based on developing fully integrated, plausible, and internally consistent "stories" about the future. Scenario analyses typically reflect three potential cases: the expected conditions over time and two bounding cases reflecting the best and worst outcomes thought possible.*

als and firms must acquire information, search for a trading partner, negotiate a deal, write a contract and enforce its terms. All of these activities add costs to market-based activities.

– *Costs of delay in the decision process* which arise because project developers typically have to acquire financing early in the development process. If the project is delayed, the **rate of return** must be increased to compensate their investors and creditors.

3.1.1 IS THE APPROPRIATE ANALYTICAL METHOD BEING USED?

A number of methods exist to analyze a given policy problem. Although choice of analytical method is both an art and a science, method selection is primarily driven by the problem — characteristics — and number of constraints both on the problem itself and the resources available to address it.

A first step in method selection is to examine the issue of concern. Questions to be considered include:

- What is the expected relative magnitude of the policy impacts — both in environmental improvements and on the activities of the regulated community?
- Is the goal to achieve a certain environmental or performance standard or to set the standard?
- Should environmental and health benefits be estimated in the analysis?
- Who might incur costs or gain benefits from meeting the policy goals?
- What is the time horizon of the analysis?
- What is the geographic and demographic scale and scope of the impacts?
- How much flexibility is allowed the regulated community in meeting the policy goals?

The descriptions of the various methods contained in Chapters Four and Five can be used to answer these questions and assess the appropriateness of employing a certain approach.

A second step is to assess the available resources to analyze the policy in terms of time, analysts, data and money.

The measurement techniques described in Chapter Four can be resource intensive. *Market-based evaluation methods* usually require the least amount of resources and frequently can be done on the "back of an envelope." Most of the required data necessary for these techniques is readily available and many analysts are trained in their use. *Regional economic models* require more time because they build on complicated economic relationships. Some credible models are available "off-the-shelf," but for smaller regions or newer policy issues, economic models must be built from scratch. *Environmental valuation methods* require much more time and money for original studies. Most of these studies rely on expensive surveys that require several months for data collection and compilation before the actual analysis is undertaken.

The analytic decision making techniques in Chapter Five usually do not require a large amount of resources beyond those used for the measurement techniques, except the time necessary to interact with decision makers and stakeholders. ***Cost-effectiveness*** and ***benefit-cost analysis*** are the most straightforward methods, only requiring a simple aggregation of the measurement technique results. ***Least-cost planning*** requires a step beyond benefit-cost analysis in that different policy actions must be weighed and ranked. ***Decision analysis*** is the most complex method because decision makers must articulate their own values as part of the process — something that might require several iterations by the analyst.

3.2 A STEP-BY-STEP APPROACH TO UNPACKING ANALYTICAL REPORTS

A STEPWISE APPROACH TO UNPACKING ANALYTICAL REPORTS

- *Read the report.*
- *Read it again.*
- *Identify the problems being addressed and the options being considered.*
- *Identify the **constraints** placed on policy options.*
  __Budget__; legal; political; economic; social; institutional; risk related; technological.
- *Identify the **baseline conditions** assumed in the analysis.*
- *Identify the analytical methods employed (Chapter Five).*
  Cost-effectiveness; benefit-cost; least-cost planning; decision analysis; risk-related analysis.
- *Identify the measurement techniques used (Chapter Four).*
- *Identify the data sources and time period covered.*
- *Identify key **assumptions**.*
- *Examine key assumptions.*
- *Identify who bears the benefits and costs of the status quo and the proposed changes.*
- *Spot check mathematics.*
- *Determine whether key policy questions have been addressed.*
- *Examine report presentation.*
  Are findings incremental, or cumulative?
- *Identify and obtain similar analyses.*
- *Discuss report with study authors.*

The other side of proactively developing an analysis is evaluating an analytical report that has already been prepared. And it is this activity — understanding existing analysis — with which this guidebook is most concerned.

The following steps should be taken to evaluate analytical reports. In undertaking these steps it is important to note that reports themselves will rarely follow the sequential pattern described below. Instead, the report reviewer may have to "search" an analysis to locate needed answers.

1. **Read the report.** It is generally a good idea to read — or at least "scan" — the report once before undertaking a serious examination. A quick read provides an analyst with a sense of the structure, content, and flow of the document and establishes an important context for the ensuing critical review.

2. **Identify the problem statement and list of alternative means of addressing the problem considered in the report.** It is important to note that the problem statement and alternatives may not include the universe of issues with which the policy maker is interested. In other words, the report scope may or may not be comprehensive. Likewise, the analysis contained in the report should exclusively focus on the stated issues.

3. **Identify the constraints on policy options considered in the report.** These constraints may or may not be comprehensive. All identified constraints should be appropriately incorporated into the analysis.

4. **Identify the baseline conditions — including ecological, technological, economic, and social — assumed in the analysis.** Baseline conditions should be consistent across analyses of like problems. For example, is an analysis of agricultural energy use based on continued groundwater overdraft in the Central Valley or does it assume that an **equilibrium** pumping level is achieved before the policy is implemented? Is a salmon fishery analysis based on predrought instream levels or existing levels? Is an analysis of the state's economy based on recessionary levels or historic average growth? **Frequently the difference between two analyses can be found in their baseline assumptions.**

5. **Identify the analytical method employed in the report.** Is, for example, benefit-cost or cost-effectiveness analysis the dominant technique used in the document? Each technique implies that different questions are under consideration. How do the questions asked in the analysis influence the findings? See Chapter Five for a discussion of these methods.

6. **Identify the measurement techniques used in the analysis.** To the extent possible analysts prefer quantitative measurement techniques. This is because two analysts working independently are more likely to produce the same results when quantitative criteria are employed (i.e.,

the analysis is more easily replicated). However, use of quantitative methods should neither preclude the use of qualitative measures, nor minimize their importance. See Chapter Four for a discussion of potential measurement variables and methods.

7. **Identify the data series, collection methods, and time period upon which the analysis is based.** Data used in analytical reports are generally derived from sources unrelated to the analysis being conducted. It is important to understand where the data comes from, so as to be able to evaluate its quality and suitability to the analysis. Section 4.6 provides a discussion of **accounting** units and stance.

8. **Identify the key assumptions upon which the analysis relies.** Key assumptions may include the following:

   - Assumptions related to the population considered by the analysis, both in terms of size and characteristics. For example, assuming that all firms in the statistical population are for-**profit** firms may lead to a different conclusion than inclusion of both for- and not for-profit firms in the study.
   - Assumptions about the benefits and costs considered by the analysis.
   - Assumptions about the geographic area considered by the analysis.
   - Assumptions related to the time horizon over which the analysis is conducted. There are a number of important issues which relate to the time period considered. For example,
     - The time horizon should match the identified issues. If the primary impact of the policy being examined is expected to occur ten years after its implementation, the analysis should extend at least ten years.
     - Appropriate economic growth rates which relate to the time period being considered should be included in the analysis.
     - Appropriate **discount rates** should be used to bring future benefits and costs to **present values**.
   - Assumptions related to technological change and the interaction between innovation rates and the policies being considered.
   - Assumptions about the characteristics of any **markets** being examined. For example, does the market at issue have a central exchange point or is it diffuse?
   - Assumptions about **uncertainty**. For example, does the analysis contain a range of possible scenarios, including the use of different assumptions?

9. **Evaluate whether the analysis reflects standard assumptions**. For example, consumers generally reduce their **demand** for **goods** and services in the face of rising **prices**; producers generally reduce production in the face of rising costs; prices of goods and services generally rise with demand; and producers tend to substitute **capital** — or technology — for labor when **wages** increase. Analytical documents should explain the rationale behind the use of non-standard economic assumptions.

10. **Identify the groups that currently pay for or benefit from existing conditions, and how benefits and costs to these groups might change under the policy being analyzed.** Policy impacts may be narrowly focused or widely dispersed. Likewise, a particular interest group may accumulate all the benefits of a proposal at a cost to the rest of the population. Or a certain locality may be forced to bear the brunt of costs for a project that benefits the entire state. Analytical reports should clearly delineate those who will benefit or sacrifice under the policy being evaluated.

11. **Spot check the mathematics presented in the report**. It is often useful to replicate some of the basic math that is used in analyses. In addition, more complex issues may merit **sensitivity testing** of the study's results.

12. **Determine whether key policy questions have been addressed**. Relevant policy questions can be grouped by whether they address economic **efficiency**, distributional impacts, risk, and the time frame of the policy action itself, as follows:

    - What are the expected net gains or costs to society resulting from the selected policy goal(s) (i.e., efficiency concerns)? What changes in net **wealth** or **income** as measured by economic activity occur as a result of achieving the stated goal? Who receives the benefits and costs engendered by the policy? Based on environmental risk, what are the net changes in ecological or resource values? What are the net values of expected health risks? See Sections 2.1.1 and 4.1.

    - How are different groups impacted by the policy goal(s) (i.e., equity concerns)? Who is burdened and who benefits from the policy? How are the disaggregated impacts of the net societal gains or costs distributed amongst various socioeconomic and geographical groups? How do noneconomic community characteristics change as a result of the policy? How do government revenues and expenditures change with a policy outcome? See Sections 2.1.2 and 4.2.

    - How much is society willing to pay for greater certainty in the future (i.e., issues of risk and uncertainty)? How great a factor is natural uncertainty in the probable success of the policy? How much uncertainty is associated with a particular technological solution versus its expected results? Will the policy have sufficient political support to be accepted and sustained? How does the policy affect businesses' financial stability? To what degree does today's **investment** in a policy foreclose tomorrow's options? Does reducing the risk to an environmental resource adequately maintain the resource for future generations? See Section 2.1.3.

- Is this the right time to invest in achieving the policy goal(s)? What is society **willing to pay** to delay implementing a policy to gather additional information that may decrease uncertainty about its outcome? Are the long-term conditions expected to differ from the current short-term situation? See Chapter Five for a discussion on various methods.
- Have all **stakeholder** voices been heard? Is society willing to sacrifice some material benefit, or to delay policy implementation to insure that due consideration has been afforded all parties.

IT'S ALL AT THE MARGIN

Marginal analysis *is one of the main analytical tools used by economists. For economists, to be "marginal" does not mean something is "borderline" or "questionable," but rather that it is "incremental." A marginal change is an increment of movement that is additional to all other changes that have already occurred. For example, a regulation may have the marginal benefit of reducing ambient ozone in an air shed by one additional ton. If existing policies already act to decrease ambient ozone to a safe level, the marginal benefit of this additional emissions reduction may be zero.*

Marginal values are quite different from ***average*** *values. For example, if the benefits associated with reducing ambient ozone by 100 tons is $100 million in decreased health care costs, the average benefit per ton is $1 million. However, the marginal benefit of the first ton of ozone reduction may be a great deal more than $1 million, while the benefit of removing the 99th ton may be much lower than $1 million, particularly if the air is already considered healthy after 50 tons of ozone have been removed.*

13. **Examine the way in which the analytical findings are presented.** For example, policy implications may be presented as incremental or cumulative.
14. **Identify and obtain similar analyses.** In some cases, either analyses of the same issue, or evaluations of a different policy but with the same decision technique, can be usefully reviewed as a method of comparing and contrasting report strengths and weaknesses.
15. **Work with the studys' authors to clarify and further explain report assumptions and methodology.** Regardless of the analytical capabilities of the reviewer, almost no report is perfectly understandable on the first or even second reading.

3.2.1 UNPACKING AN ANALYTICAL REPORT: A CASE STUDY

This section further describes the handbook's recommended stepwise process of analytical evaluation by presenting a case study report assessment. The document selected for this case study — *Commuting, Congestion, and Pollution: The Employer-Paid Parking Connection* — published in 1992 by the Reason Foundation — was not chosen because it is a "good" or "bad" report. Rather, the report reflects a complex and topical issue and provides a rich source to investigate application of the analytical tools discussed in this handbook.

After "Step One, Read the Report," applying Section 3.2 steps to the study results in the following evaluation:

STEP TWO IDENTIFY THE PROBLEM STATEMENT AND LIST OF ALTERNATIVE MEANS OF ADDRESSING THE PROBLEM CONSIDERED IN THE REPORT

Commuting, Congestion, and Pollution: The Employer-Paid Parking Connection (or *Parking Connection*) was undertaken to evaluate changes in polluting air emissions, traffic congestion and associated economic impacts that would be **induced** by a proposal to amend the Internal Revenue Code's so-called "special rule for parking." The proposed amendment would allow employees the option either to receive the fair market value of employer-paid parking as taxable cash income or to continue to receive employer-paid parking on a tax-free basis. Specifically, the report authors propose that the Internal Revenue Service's special rule for parking be amended as follows:

> The term "working condition fringe" includes parking provided to an employee on or near the business premises of the employer if the employer offers the employee the option to receive, in lieu of parking, the fair market value of the parking subsidy, either as a taxable cash commute allowance or as a mass transit or ridesharing subsidy.

Employer-paid parking is a form of matching grant whereby an employer offers to pay an employee's parking costs if the employee is willing to pay all other work-related driving expenses. *Parking Connection* estimates that in 1986 69,503 workers in the Los Angeles Central Business District (LA-CBD) were offered employer-paid parking.

Although there are a number of other methods of addressing traffic congestion and mobile source air **pollution**, the analysis contained in *Parking Connection* is limited to the one alternative outlined above. The report does, however, refer the reader to other studies which examine potential methods of reducing congestion and associated polluting emissions.

STEP THREE IDENTIFY THE CONSTRAINTS ON POLICY OPTIONS CONSIDERED IN THE REPORT

Parking Connection does not explicitly identify potential constraints — legal, institutional, or economic — on policies to address traffic congestion and mobile source polluting air emissions. However, the report implicitly notes that political **sustainability**, ease of implementation, and impacts on public and private sector costs are of some importance to the success of any congestion-related proposal. For example, *Parking Connection* argues that the proposed policy has several advantages that may make it easier to implement than alternative mechanisms to address congestion and air pollution. These advantages include:

1. No employee would lose any existing parking subsidy.
2. Offering commuters the option to choose between free parking and cash means that parking would have an **opportunity cost** — the cash not taken, thereby encouraging employees to make a conscious choice about their actions.
3. Employers would be no worse off than the existing system if an employee chooses the cash alternative.
4. The **lowest-paid** workers would gain the most after-tax cash from the policy because they are in the lowest tax brackets.
5. The policy would be easy to implement and enforce, since it would require employers to report any tax-exempt parking subsidies on their employee's payroll forms in the same way they already report tax-exempt fringe benefits.
6. Federal and state income tax revenues would increase when employees choose to receive cash in lieu of free parking since cash is taxable.

STEP FOUR IDENTIFY THE BASELINE CONDITIONS — INCLUDING ECOLOGICAL, TECHNOLOGICAL, ECONOMIC, AND SOCIAL — ASSUMED IN THE ANALYSIS

To evaluate the impacts of the proposed statutory change, *Parking Connection* first summarizes the existing implications of employer-paid parking in the Los Angeles CBD in terms of vehicle miles travelled, gasoline consumption, transportation expenditures and associated air pollution and traffic congestion. The report then compares this baseline to the estimated impacts that would result from offering workers the option to cash out the value of employer-paid parking.

Since publication of *Parking Connection* several changes have occurred which, if incorporated into a revised baseline, could result in different benefits than those estimated in the report. For example, since 1992 the Metro Red Line has opened in Los Angeles, and since 1993 the dollar value of employer-paid parking above

$155 per month is counted as taxable income by the federal Internal Revenue Service. However, without further analysis it is unclear whether or not these changes would act to reduce or increase the estimated benefits associated with the policy.

STEP FIVE IDENTIFY THE ANALYTICAL METHOD EMPLOYED IN THE REPORT

The primary focus of the report is to assess the economic efficiency implications of the proposed alternative. *Parking Connection* does not address how the benefits and costs of employer-paid parking are currently distributed across different geographic areas or socioeconomic groups, nor how this distribution would change as a consequence of the proposal. In particular, while the report asserts that **low-income** commuters would benefit disproportionately from the policy because they are in lower tax brackets, it does not provide compelling evidence to support this claim. Likewise the study fails to identify clearly the costs to be borne by employers as opposed to employees. *Parking Connection* does, however, refer the reader to an earlier publication which attempts to address some of these issues (step fourteen).

STEP SIX IDENTIFY THE MEASUREMENT TECHNIQUES USED IN THE ANALYSIS

Parking Connection relies on statistical analyses of a 1986 survey of 5,060 employees, working for 118 employers, in downtown Los Angeles. The survey was designed to be representative of the entire population of office workers in the LA-CBD. Based on this survey data, the report authors developed a **regression** model (logit) that included employer-paid parking as an independent **variable** along with other customary variables, such as income, occupation, travel time, and travel cost to work. This logit model was used to predict how employer-paid parking affects commuters' travel choices.

To assess the economic impacts and changes in travel behavior associated with the proposed policy, the report estimates changes in commuter behavior that would be induced by an increase in parking prices equal to the after-tax cash value of the tax-exempt parking subsidy each commuter would be offered. Because the report does not include a detailed description of the 1986 commuter survey or the **statistical** results of the regression model, it is not possible to evaluate the quality of these analyses in more detail (see Chapter Four). In this case, it would be useful to examine earlier publications — which are referenced in the report — which include a more detailed description of the commuter survey and the statistical results of the regression model (step fourteen).

As indicated in Tables One and Two, estimated impacts on a number of variables include the following:

Solo Drivers: The report estimates that provision of free employee parking (i.e., the status quo) in Los Angeles' Central Business District increases the share of solo drivers in the area from 48 percent to 69 percent, a 44 percent increase overall. Offering employees the option to cash out employer-paid parking (i.e., the proposed policy) is estimated to reduce the share of solo drivers from 69 percent to 55 percent, a 20 percent decline.

Parking Demand: The per employee spending on parking by all employees who are not offered employer-paid parking — including transit users and carpoolers — in LA-CBD is $563 annually. In contrast, the per employee spending on parking for all employees who are offered employer-paid parking is $750 a year. Employer spending on parking is high because the quantity of parking demanded by commuters when it is provided to them for free is 34 percent greater than the quantity demanded at market prices (i.e., demand forces price up). On an aggregate level, employer-paid parking policies act to increase total parking expenditures in downtown Los Angeles from $39 million to $52 million annually or by $13 million a year.

Parking Connection estimates that if a cash option were offered to employees, employer spending on parking would decline to $626 per employee per year on average (i.e., spending per employee per year would fall by $124 as a result of reductions in parking demand). In aggregate, the report estimates that introduction of a cash option would decrease total parking expenditures by approximately $9 million.

Vehicle Miles Travelled (VMT): Some employees currently respond to employer-paid parking by shifting from carpools and mass transit to solo driving. This behavior increases automobile VMT. For example, commuters who pay to park drive 18.1 VMT per day, while commuters who are provided with employer-paid parking are estimated to drive one-third more: 24.1 VMT per day. The additional six VMT per day per employee induced by employer-paid parking results in an aggregate 1,311 VMT per employee per year. On an aggregate basis, the report estimates that employer-paid parking acts to increase VMT per year in Los Angeles from 272 million to 363 million miles, an increase of 91 million miles.

Parking Connection estimates that providing the option to cash out the value of parking would decrease VMT per day from 24.1 to 20.1 VMT. This 4 VMT per day reduction corresponds to an 868 VMT decline per employee annually. On an aggregate basis, the report estimates that the cash-out option would decrease annual VMT from 363.4 million miles to 304.6 million miles, a decrease of 58.8 million miles or about 16 percent.

Gasoline Consumption: Commuters who pay to park use 231 gallons of gasoline per year on average to drive to and from work, while commuters who receive employer-paid parking are estimated to consume 308 gallons of fuel per year. This corresponds to an aggregate increase in gasoline consumption of 5.3 million gallons due to the employer-paid parking policy, from 16 million gallons to 21.4 million gallons.

Parking Connection estimates that provision of the cash-out option would decrease gas consumption to 258 gallons per year per employee. On an aggregate basis this corresponds to a decrease in gasoline consumption of 3.5 million gallons to 17.9 million gallons.

Transportation Expenditures: *Parking Connection* estimates that employer-paid parking acts to increase spending on parking by $187 per employee per year (see Parking Demand above) and acts to increase employee spending on driving by $380 per year. On an aggregate basis, this means that expenditures for automobile use and parking are estimated to increase by $39.4 million per year as a result of employer-paid parking, from $118.2 million to $157.3 million.

The report estimates that provision of a cash option would decrease spending per employee on parking by $124 per year and would decrease employee spending on driving by $246 per year — a total decrease of $370 per employee annually. In aggregate, this corresponds to a decline in private costs from $157.7 to $131.6 million — a savings of $26.1 million per year.

Because employer-paid parking increases VMT, it also increases the external (social) costs of automobile use in Los Angeles. *Parking Connection* attempts to estimate the increased costs of air pollution and traffic congestion induced by employer-paid parking. However, the report does not attempt to quantify other external costs, such as property value declines related to increased noise, aesthetic degradation, neighborhood disruption, road maintenance and operation costs, or contributions to global climate change. Estimated impacts on congestion and air pollution are presented below.

Congestion Costs: Traffic congestion is a major external cost of solo driving, because when one more automobile uses a road that is already near capacity, the additional car causes traffic to move more slowly, thereby imposing costs on other drivers and transit riders.

Parking Connection estimates that employer-paid parking acts to increase congestion costs by $262 annually per employee to whom it is offered. These additional expenses represent a 33 percent increase in congestion costs, from $784 to $1,046 per employee per year. On an aggregate basis, these costs correspond to an increase of $18.2 million, from $54.4 million to $72.7 million. The report estimates that provision of an option to cash out employer-paid parking would reduce the **external** costs of congestion by $11.8 million per year, to $60.9 million annually.

Pollution Costs: On average, commuters who pay to park impose air pollution costs of $157 per year, and those who park free impose air pollution costs of $209 per year — a difference of $52 annually. On an aggregate basis, these additional expenses correspond to an increase in air pollution costs of $3.6 million, from $10.9 million to $14. 5 million. Offering employees an option to cash out free parking is estimated to decrease pollution costs by $2.3 million to $12.2 million annually.

Based on the figures presented above, employer-paid parking is estimated to increase the total cost (private plus social) of automobile use in Los Angeles by $61.3 million, from $183.6 million to $244.9 million. By offering employees the option to take cash in lieu of employer-paid parking, the social costs of automobile use is estimated to fall $40.2 million, from $244.9 to $204.7 million — a 16 percent decline.

Table One
Travel Behavior & Expenditures of Commuters to LA Central Business Destrict

Behavior/Expenditure	Driver Pays to Park	Employer Pays for Parking: W/O Cash Option	Employer Pays for Parking: With Cash Option	Difference
Solo Driver Share (percent)	48	69	55	14
VMT (per employee per day)	18.1	24.1	20.0	4.1
VMT (per employee per year)	3,919	5,230	4,383	847
Gas Used (gallons/employee-year)	231	308	258	50
Parking Expenditures ($/employee-year)	563	750	626	124
Employees ($/employee-year)	563	0	0	0
Employers ($/employee-year)	0	750	626	124
In Lieu Cash Expend. ($/Emp-yr)	**0**	**0**	**380**	**(380)**
Auto Use Expenditure ($/employee-year)	1,137	1,517	1,271	246
Parking & Auto Expend ($/employee-year)	**1,700**	**2,266**	**1897**	**369**
Park & Auto & In Lieu Cash Expenditures ($/employee-year)	**$1,700**	**$2,266**	**$2,277**	**$(11)**

Assuptions:
(1) Days worked per year = 217
(2) Auto Use Cost = $0.29 per mile
(3) Auto Fuel Efficiency = 17 mpg
(4) Cost of Parking = $83.82/month; $1,006/year

Source: Shoup, D.C., and R.W. Wilson, Commuting, Congestion, and Pollution: The Employer-Paid Parking Connection, Policy Insight No. 147, Reason Foundation, Sept. 1992.

Table Two
Travel Costs of Commuters to LA Central Business Districts

Behavior/Expenditure	Driver Pays to Park	Employer Pays for Parking: W/O Cash Option	Employer Pays for Parking: With Cash Option	Employer Pays for Parking: Difference
VMT (millions per year)	272.4	363.4	304.6	58.8
Gasoline Consumption (million gallons)	16.0	24.1	17.9	6.2
Congestion Cost ($millions/year)	54.4	72.7	60.9	11.8
Pollution Cost ($millions/year)	10.9	14.5	12.2	2.3
Total External Cost ($millions/year)	65.4	87.2	73.1	14.1
Auto Use Expenditure ($million/year)	79.0	105.4	88.3	17.1
Parking Expenditure ($million/year)	39.2	52.3	43.3	9.0
Employees ($milliions/year)	39.2	0	0	0
Employers ($millions/year)	0	52.3	43.3	9.0
In Lieu Cash Expend. ($millions/year)	0	**0**	**26.6**	**(26.6)**
Private Cost of Auto Use (1) ($)	**118.2**	157.7	131.6	26.1
Social Cost of Auto Use (2) ($)	183.6	244.9	204.7	40.2
Adjusted Private Cost of Auto Use (3) ($)	**118.2**	**157.7**	**158.2**	**(0.5)**
Adjusted Social Cost of Auto Use (4) ($)	183.6	244.9	231.3	(13.6)

Assumptions:
(1) Days worked per year = 217
(2) Auto Use Cost = $0.29 per mile
(3) Congestion Cost = $0.20 per mile
(4) Number Offered Free Parking = 69,503
(5) Auto Fuel Efficiency = 17 mpg
(6) Cost of Parking = $83.82/month; $1,006/year
(7) Pollution Cost = $0.04 per mile

Source: Shoup, D.C., and R.W. Wilson, Commuting, Congestion, and Pollution: The Employer-Paid Parking Connection, Policy Insight No. 147, Reason Foundation, Sept. 1992.

Footnotes:
(1) Driving Plus parking ($millions/year) as reported in Shoup, et al. (1992).
(2) Private plus external ($millions/year) as reported in Shoup, et al. (1992).
(3) Driving plus parking ($milliions/year) as recalculated by Diamant (1993).
(4) Private plus external ($millions/year) as recalculated by Diamant (1993).

STEP SEVEN IDENTIFY THE DATA SERIES, COLLECTION METHODS, AND TIME PERIOD UPON WHICH THE ANALYSIS IS BASED

Most of the data used in *Parking Connection* is for 1986, with several notable exceptions. In particular, the report relies on estimates of congestion costs that appear to represent a middle value across a variety of studies published between 1986 and 1991. The most recent study cited [Cameron, 1991] estimates a congestion cost of between $0.01 to $0.37 per mile travelled. In addition, the report relies on estimates of the external cost of air pollution that are based on 1987 data.

The use of data of different vintages is not particularly troublesome. However, the apparent mixing of costs displayed in 1986 and 1987 current dollars represents a minor methodological flaw. The report could be improved by recalculating estimated costs in terms of **constant dollars** for a given base year. By so doing all of the costs (e.g., the private costs, congestion costs and air pollution costs) would be directly comparable. However, given the significant range of uncertainty associated with congestion costs — which are estimated at anywhere between one cent to 37 cents per mile — this modification would not likely affect the report's findings.

STEP EIGHT IDENTIFY THE KEY ASSUMPTIONS UPON WHICH THE ANALYSIS RELIES

Parking Connection relies on a number of assumptions, including the following:

Days worked per year	=	217
Number of People Offered Free Parking	=	69,503
Congestion Cost	=	$0.20 / mile (1991)
Air pollution cost	=	$0.04 / mile (1991)

Although the assumptions used in *Parking Connection* seem plausible, they provide a good opportunity to examine the use of weighted **averages**, arithmetic **means**, or **median** values in analytic reports. The choice of which type of average to use could greatly influence the report's findings. For example, Table Three displays the comparison of "average" commuting distances. Based on the number of cars, round-trip commuting distance, and average number of riders, the difference between mean, median, and weighted average values is quite significant. As shown in the table, the mean commuting distance is 25.8 miles, the median distance equals 10.0 miles and the weighted average distance is equal to 32.2 miles.

Table Three

A Comparison of "Averages"

Number of Cars	Length of Commute (Miles)	Average Number of Riders per Car
2,000	5	1
1,000	10	1
1,000	15	2
1,000	20	2
1,000	100	2

Mean Length of Commute	=	25.8 miles
Median Length of Commute	=	10.0 miles
Weighted Average Length of Commute	=	32.2 miles

Parking Connection does not explore the range of uncertainty associated with various assumptions. Given that estimated congestion costs vary significantly, the report would benefit from a presentation of the outcomes associated with use of different congestion cost estimates (e.g., sensitivity testing).

STEP NINE EVALUATE WHETHER THE ANALYSIS REFLECTS STANDARD ASSUMPTIONS

In general, the report appears to follow standard analytical assumptions. However, because the analysis is static, *Parking Connection* ignores the impact that the policy-induced decline in parking demand would have on parking prices. Based on standard economic theory of supply and demand, a 20 percent decrease in private vehicle commuting would act to put downward pressure on parking rates. Employers would realize savings both through lower parking and cash-out expenditures.

STEP TEN IDENTIFY THE GROUPS THAT CURRENTLY PAY FOR OR BENEFIT FROM EXISTING CONDITIONS, AND HOW BENEFITS AND COSTS TO THESE GROUPS MIGHT CHANGE UNDER THE POLICY BEING ANALYZED

As previously discussed, *Parking Connection* focuses on the aggregate benefits and costs of the proposed policy rather than the distribution of benefits and costs. However, the narrow focus of *Parking Connection* may lead readers to ignore important resource transfers — from employers to employees — that could occur within the overall rubric of the proposal. Under current law conditions, a total of 69,500 employees are offered free parking, of which 52,100 actually occupy employer-financed parking spaces at a employer cost of $52.4 million. Given the option of accepting cash in lieu of free parking, the report estimates that 43,100 employees would continue to choose free parking, at a cost of $43.4 million, and approximately 9,000 employees would trade their parking spaces for cash, at a cost of $9 million. However, 17,400 employees who had previously declined free parking — and received nothing from their employer — would take the cash equivalent of $1,006 per year. These drivers would be provided with $17.4 million a year in cash payments from their employers. As a result, proposal implementation would engender continued employer payments of $43.3 million for parking; a transfer of $9 million from parking expenditures to cash payments to formerly "parked" employees; and an additional $17.4 million a year in direct cash outlays, a transfer which the report neglects to include in its analysis. Total employer expenditures under the proposed alternative would be $69.9 million annually instead of the reported $52.4 million — $17.4 million higher than estimated in the report (see also step thirteen).

Although this additional transfer of resources may not affect the overall *social* benefits of the policy, it does have important policy implications. First, *Parking*

Connection claims that one of the advantages of adopting the proposal alternative would be that "...employers are no worse off if an employee chooses the cash alternative or gives up the parking subsidy because the cash alternative is no more costly than the parking subsidy." However, the data presented in the report indicates that this claim is incorrect. Although it is true that the employer-specific cost of offering a *single* employee free parking or a cash payment is equal, offering *all* employees the option of receiving cash in lieu of free parking would be substantially more costly to employers than simply providing free parking. The large difference in out-of-pocket costs stems from the fact that employers would bear the costs of providing *all* employees either cash or free parking under the proposed alternative, while they only bear the costs of providing parking for employees who drive to work under the current employer-paid parking rules.

Second, given that employers may be unwilling to spend additional sums on their parking programs, in the face of a cash-out policy they may modify their parking programs entirely, potentially imposing greater restrictions on access to it. Such a change, however, could result in similar outcomes as predicted in the report — fewer employees would be eligible for free parking and would drive to work, thereby reducing the social costs associated with private vehicle commuting.

Third, if employers do not or, for some reason, cannot modify their parking policies in the face of the cash-out option, the transfer of resources from employers to employees would result in some change to local economies. In the case described in *Parking Connection*, almost $20 million which originally had been spent on employer-driven goods and services would instead be spent on consumer-driven goods and services, with concomitant changes to local suppliers. Such a transfer could also encourage employers to relocate to localities where less expensive parking is available.

And finally, it is unclear from the report analysis how rapidly employers can move in and out of the parking market. For example, it is possible that under the policy employers would have to both finance the cash out and the expense of excess parking places. In this sense, the report findings reflect a **partial equilibrium** analysis.

STEP ELEVEN SPOT CHECK THE MATHEMATICS PRESENTED IN THE REPORT

A random check of report mathematics did not identify any calculation errors.

STEP TWELVE DETERMINE WHETHER KEY POLICY QUESTIONS HAVE BEEN ADDRESSED

Parking Connection suggests several broad policy implications that are generally supported by the presented data. First, employer-paid parking appears to encourage more commuters to drive to and from work in Los Angeles; increases regional traffic congestion and air pollution; and increases the amount of society's resources spent on driving and parking. Second, elimination of employer-paid parking would reduce reliance on automobiles; decrease traffic congestion and air pollution; and free up society's resources to be used to pay for alternative goods and services. Third, the proposed alternative — to allow employees to receive cash in lieu of free parking — would provide many of the same benefits as eliminating employer-paid parking but may be easier to implement and enforce than a complete ban on employer-paid parking. While these findings appear to be fairly **robust**, it is unclear from the report the extent to which they are generalizeable to areas outside of the LA-CBD.

Partially as a result of the research contained in *Parking Connection*, the State of California recently enacted legislation which requires employers to offer their employees a cash allowance equivalent to the parking subsidy that the employer would otherwise pay to provide the employee with a parking space. In addition, the Clinton Administration included the parking cash-out proposals as the primary transportation measure in its *Climate Change Action Plan* to reduce **greenhouse** gas emissions and has announced its intention to submit cash-out legislation to Congress in 1994.

STEP THIRTEEN EXAMINE THE WAY IN WHICH THE ANALYTICAL FINDINGS ARE PRESENTED

Other than the potential reader confusion that could be engendered by the issues identified in step ten, report findings are clearly and comprehensively presented.

STEP FOURTEEN OBTAIN SIMILAR ANALYSES

As indicated in the previous steps, there are a number of reports — some of which were developed by the authors of *Parking Connection* — that could be usefully examined as part of a comprehensive analysis of the issue. The existence of these reports points to the need both to avoid examining a single report in isolation and the importance of dedicating specific Cal/EPA staff to ongoing issues, so that they can develop an expertise in the subject area.

STEP FIFTEEN WORK WITH THE STUDY'S AUTHORS TO CLARIFY AND FURTHER EXPLAIN REPORT ASSUMPTIONS AND METHODOLOGY

The report authors provided important insights into their analytical findings after the initial study review had been completed. In addition, the authors indicated that the evaluation conducted by the handbook authors prompted additional attention to a number of key issues — including the implications of the employer to employee resource transfers discussed in step ten — which would be further explored in future research.

4 MEASURING OBJECTIVES AND UNINTENDED CONSEQUENCES

Once an analytical structure has been used to define a problem, having a "measurable" policy objective does not mean that the outcome must be denominated in monetary terms. Analytic decision making methods are available for weighing multiple goals and objectives described in different terms. A decision maker should be ready to attach "weights," either explicitly or implicitly, to the various goals within a proposed policy. This concept should not be surprising since policy making always involves trade-offs in what society wants to attain.

As noted in Chapter Three, a key feature of analytic decision making is its ability to identify objectives and develop means of measuring their attainment. In addition to the desired policy goals, **government** intervention can also result in unintended consequences, which can also be assessed using various measurement **variables**. These policy "yardsticks" fall into two general categories: **economic efficiency** and distributional impacts.

Although distributional and efficiency concerns are frequently measured using the same variables — such as job or **income** changes — it is important to understand the distinction between the two. Efficiency criteria focus on aggregate benefits and **costs**, or the overall **economic** changes induced by a policy. For example, assigning a parking place close to a building to an employee who drives to work every day may be efficient. Distributional criteria focus on who receives the benefits or costs of a policy. For example, the parking space may be provided to the boss as a perk.

The evaluation methods described in this chapter represent those most commonly used in policy analysis reports and include the following:

Market-based Evaluation Methods

- **Engineering economics** or **life-cycle analysis** is used to determine the costs of purchasing, installing and using a long-lived economic **asset** such as a building or automobile.

- **Discounted cash flow and internal rate of return** are used to weigh the costs of purchasing and using an asset against the income and other benefits that the asset provides over a period of time. This method provides a simple assessment of the returns to investing in an asset.
- **Mathematical-programming** models are used to determine the best mix of resource inputs required to produce a certain output (e.g., the amount of land, fertilizer, water, equipment and labor needed to achieve a certain crop yield that maximizes a farmer's **profits**).
- **Econometric analysis** is a **statistical** method of assessing past economic behavior, such as the sensitivity of **demand** to changes in prices or how changes in inputs affect production.
- **Accounting analysis** uses the financial characteristics of particular firms to estimate the impacts on costs and production from policy changes. This method serves as a useful measure of short-term effects and a check against the findings of more sophisticated techniques.

Regional Economic Impact Models

- **Input-output models** provide a simple analysis of the economic flows through a regional or national economy that result from policy changes.
- **General equilibrium models** are more sophisticated regional impact models that take into account that the value of a resource changes as the mix of other resources and demand for a product change.

Valuing Environmental Assets and Health Benefits

- **Hedonic pricing** uses the differences in the value of comparable fixed economic assets, such as houses, to assess the **market price** attached to environmental quality (e.g., air and water quality, existence of vegetation or a view).
- **Travel-cost method** estimates the value for a recreational asset by calculating how much individuals are willing to expend in travel time and cost to reach the location.
- **Contingent valuation methods** ask people directly how much they value an environmental asset for which a market does not exist (e.g., the continued vitality of wetlands).
- **Politically-revealed preferences or control costs** represent the value placed on protecting against damage to the environment or health through the political process. This approach uses the costs of meeting regulatory standards

as the proxy for the benefits of reducing environmental or public health risks.

- **Damage functions** take scientifically derived physical changes to the environment and apply these impacts to economically estimated values for environmental **attributes** to calculate expected damages from specific contaminants, hazards or actions.

Frequently a mix of these methods will be used in an analytic report. For example, damage functions often use values derived from **contingent valuation** studies, and programming models rely on engineering economics and **econometric** analyses for their initial cost estimates.

4.1 MEASUREMENTS OF ECONOMIC EFFICIENCY: WHAT ARE THE NET GAINS TO SOCIETY?

Economic efficiency is concerned with the expected net gains or **costs** to society resulting from a policy choice. Efficiency-related economic **attributes** associated with environmental policies tend to fall into one of three categories, as follows:

- ***Direct economic impacts*** - focus on changes in net **wealth** or **income**. This encompasses one component of economic well-being — aggregate societal benefits and costs. Measured changes include **productivity**, employment, income, potential **direct cost** increases or savings to consumers or producers, and **indirect** or secondary impacts on consumers or producers through changes in economic activity.

  In assessing direct economic impacts, it is important to avoid double counting benefits and costs. For example, higher incomes generally lead to inflated land prices, so higher purchase and rental costs should be netted out of aggregate wealth increases. *Regional impact, mathematical programming and input-output models are used to evaluate these impacts.*

IS AN EMPLOYED SOCIETY A WEALTHY SOCIETY?

More jobs do not necessarily mean more societal ***wealth****. The kinds, as well as the total number, of jobs created are of importance to wealth generation. For example, in low-income Bangladesh it takes many more workers to grow and harvest a ton of rice than in wealthy America, yet few would argue that Bangladesh, with more rice-related jobs, is better off than the United States. The use of labor is but one variable in the economic equation, and* ***efficiency*** *gains depend on how the many relevant factors in this equation —* ***technology****, resources, education levels, among others — interact.*

- ***Environmental and aesthetic amenities*** - focus on net changes in ecology or resources, including ecological restoration, as measured by the reintroduction and ongoing well-being of specific animal and plant species into an area. Although the natural sciences are employed to measure **ecosystem** changes, economics can be employed to translate natural attributes into monetary values. These characteristics — including functioning natural ecosystems with abundant wildlife; recreational opportunities; ambient levels of noise, dust and odors; visibility; landscape — must be <u>valued</u> by individuals in some manner. *Nonmarket valuation techniques, such as **hedonic estimation, contingent valuation** and **travel-cost models**, are used to quantify approximately the monetary benefits of natural resources.*

- ***Human health aspects*** - are concerned with the net value of expected health **risk** reductions. Health **attributes** are either related to reducing the chance of death (mortality) or decreasing the incidences of illness (morbidity). While health scientists are primarily responsible for measuring changes in mortality or morbidity, economic methods can be used to translate these changes into dollar terms. For example, economic benefits and costs can be associated with avoiding illness or death attributable to pollutants and toxics; the value of lives lost or disrupted; the value attached to "peace of mind" or anxiety about potential health threats engendered by environmental hazards. *Nonmarket evaluation methods are used — including **damage functions** based on **dose-response models** and hedonic estimation — to estimate the economic value of morbidity and mortality.*

4.2 MEASUREMENTS OF DISTRIBUTIONAL IMPACTS: WHO ARE THE WINNERS AND LOSERS?

Distributional concerns center on a policy's implications to different groups, including who is burdened and who benefits from the policy. Distributional impacts fall into one of four categories, as follows:

- ***Equity impacts*** - include effects on various **socioeconomic** and geographical groups. **Equity** impacts focus on the **economic** well-being of individuals or groups. Equity-related **costs** and benefits include:

  Jobs - Employment changes can be measured by identifying economic sectors which gain or lose jobs as a result of a policy and by evaluating the overall "**churning**" effect induced.

  Income and wealth - Job and income changes can be specified and quantified by **income**, number of individuals affected, **mean** and **median** income, and job changes within a class.

Regional impact and input-output models can be used to identify equity impacts by economic sector; and demographic distributional models can be used to identify geographically determined impacts.

PROFIT FUNCTIONS

In examining the profit motives and cost factors for producers, economists develop ***profit functions*** *that represent a simple model of a firm's financial and technological traits. A profit function has four components:*

- ***Revenues*** *equal the price of the product or service times the quantity of output.*
- ***Costs*** *equal the price of inputs — such as labor or investment — times the quantity of inputs.*
- ***Constraints*** *on resource availability.*
- ***Technology*** *is reflected by a mathematical representation of the production process—the* ***production function****—that describes how inputs are combined to produce an output.*

Assumptions *frequently made to support profit functions include:*

- *Firms are in a* ***competitive market*** *(i.e., the prices for products and inputs are not influenced by the behavior of an individual firm).*
- *Firms have access to* ***perfect information*** *about present and future conditions, which may be conveyed through the market's pricing mechanism.*
- *Firms are* ***risk-neutral*** *about their choices (i.e., they are indifferent between two choices that have the same expected outcomes, regardless of whether one may involve higher risks).*
- *The world is unchanging or* ***static****, implying that no dynamic feedback effects exist.*
- *The production process eventually has* ***decreasing returns to scale*** *(i.e., the cost of producing each additional unit increases with total output).*

Obviously, these assumptions are not always even good approximations of a particular situation and must be modified to accurately assess the problem. On the other hand, the analysis becomes more complex as the assumptions are adjusted to accommodate real-world conditions such as ***monopolies, uncertainty*** *and* ***dynamic*** *effects.*

- ***Community amenities and cohesiveness*** - focus on the desirability of a community-wide change induced by a given policy. Included in this category is an evaluation of the nonmarket attributes that affect the desirability of a community (e.g., vitality, interrelationships, crime rates, education level, congestion and urban sprawl, and interclass tensions). The category also includes cultural factors, such as ethnic identity, religious practices and other bases of community organization. *In general, these factors are difficult or impossible to quantify using solely economic techniques. The disciplines of sociology and psychology can be usefully employed to examine these issues.*

- ***Relative competitiveness*** - relates to the desirability of a political jurisdiction as a place to locate a business. This factor can be affected by government services and regulatory levels, availability and cost of key market inputs, and the attractiveness of the environment and community. *While attempts have been made to rank various locales for their attractiveness based on a variety of* ***attributes*** *— including regulatory burden, workforce training and education, crime rates, climate, tax rates, and housing costs — economists have not developed a single quantifiable "index" to measure business climate.*

- ***Fiscal impacts*** - focus on how government revenues and expenditures change as a result of a policy. Government revenues are derived from economic activity. As a result, changes in this activity will affect public sector revenues, and potentially the level of government services. For example, property tax breaks for a large factory may lead to lower aggregate property tax revenues but increased business activity, which in turn

CONSUMER PREFERENCE OR UTILITY FUNCTIONS

Economic analysis typically focuses on the individual as the core of the decision making process. Consumers are assumed to make choices that best satisfy their preferences given ***budget*** *and* ***income constraints****. Economists assume that consumers have roughly similar preference functions, and that these preferences can be aggregated among individuals to determine the total social net benefit associated with an activity.*

Other typical assumptions about consumer preferences include:

- *Consumers can best decide for themselves what they want, and others' preferences do not affect their own choices.*
- *Consumers have preferences about all available goods and services, and these preferences are separable among goods and services.*
- *Consumers have well-ordered, consistent or* ***transitive*** *preferences among goods and services.*
- *Consumers do not exhibit large discrete jumps in their preferences (i.e., they care about a particular good until it reaches some threshold level at which point they care a substantial amount).* ***Ecosystems****, on the other hand, may follow such behavior (e.g., aquatic life often can tolerate heavy metal contamination up to a threshold, beyond which the ecosystem fails).*
- *Consumers always prefer more of a good or service in the range of analysis (i.e., "more is better").*
- *As consumption of a good increases, the benefit of an additional unit provided eventually decreases.*
- *Consumers are either* ***risk-neutral*** *or* ***risk-averse*** *(i.e., they prefer certainty over risky situations).*

could engender higher sales and income tax revenues, and, in the long run, higher property tax values as the **wealth** of the community grows. However, regional fiscal policies often simply shift revenues from one jurisdiction to another (e.g., competition for professional sports franchises). *Government revenue projection models can be used based on regional impact and* ***macroeconomic*** *models to project fiscal impacts.*

4.3 MEASURING MARKET-TRADED GOODS AND SERVICES

There are a number of different ways to measure changes in **market-based** economic activity. These include:

- **Internal rate of return** or discounted cash flow,
- Engineering economics,
- **Mathematical-programming** models,
- **Statistical** and **econometric** analysis,
- Accounting analysis,
- Regional economic impact modeling techniques,
- **Static** simple **equilibrium** model,
- Input-output models, and
- **General equilibrium** regional models.

Each of these measurement techniques is evaluated below.

4.3.1 DISCOUNTED CASH FLOW AND INTERNAL RATE OF RETURN

Description: Discounted cash flow (DCF) and Internal Rate of Return (IRR) are two related and useful means of comparing the economic benefits of alternative projects. When comparing projects with different time periods, it is not enough to know costs and benefits. The timing of the **flows** of benefits and costs must also be considered. DCF uses a specified **present-value discounting rate** (PVDR) to account for the **time value of money**. This rate can be used to take into account the implications of **inflation**, **opportunity costs** and payback **risk**. Summing the DCF over the life of the project yields the **net present value** (NPV). In general, the higher the NPV, the more desirable the project, while a project with a negative NPV is not worth doing (see also Section 5.2 Benefit-Cost Analysis).

IRR analysis is an application of DCF in which the time value of money is taken into consideration but not by any explicitly specified PVDR. Instead, a PVDR which results in a net present value of zero is calculated. This calculated PVDR, expressed as a percentage, is defined as the IRR. The higher the IRR,

TIME IS MONEY

*Things change as time goes by. We all get older, equipment wears out, and new technologies are developed. Money too "degrades" and generally loses value over the years. This is chiefly because of **inflation**, lost earning potential, and **risk**, all of which act to eat away at our purchasing power. For example, fifty years ago a favorite candy bar could be had for a nickel; today the same luscious mound of nuggety chocolate costs sixty cents. While sometimes the value of a dollar increases — California real estate in general requires fewer dollars to purchase in 1994 than it did in 1990 — over time dollar value tends to steadily degrade.*

*Because time is the enemy of money, in general a dollar today is worth more than a dollar tomorrow. In addition to inflation, **interest** may include a factor that reflects the value of the money as a source for capital **investment**, with higher value associated with more risky, but potentially more lucrative, projects. That is one of the reasons financial institutions are willing to pay interest to hold on to our paychecks. This is called the **time value of money**.*

the greater the benefits of the project. The IRR in effect shows the percent payback of the investment. A negative IRR indicates that the project is not worth doing. Most spreadsheet programs have a built-in formula to compute the IRR.

Data Requirements: For both DCF and IRR the cash flow—that is the stream of costs (investments) and returns (benefits or payback)—must be specified over the project's life. Cost or investments are negative cash flows, while benefits or payback are positive cash flows. For each year, the net benefits (benefits minus costs) are summed. In DCF, these are discounted back to a base

TIMEFRAME BANDITS

*Failure to establish a common timefame can lead to suboptimal decisions. For example, consider a decision between two air pollution control devices to be made on the basis of **cost effectiveness**. Device A has an installed (capital) cost of $100 and a $10 per year operating cost. Device B, which is equally effective as Device A in controlling **pollution**, has an installed cost of $200 and an operating cost of $5 per year. Which device is more cost effective? After 10 years device A has a total cost of $200 (at a zero present value discount rate). Device B has a total cost of $250. Is A more cost-effective? The answer is "yes" for a 10-year timeframe but "no" for a 25-year timeframe. After 25 years A costs $350 while B costs $325. What if device A has an operating life of 15 years while B lasts 20 years? A is cost effective for a 15-year timeframe, B is cost effective for a 20-year timeframe, but A wins for a 30-year time frame.*

year using the PVDR. If costs and benefits are expressed in **real** (constant dollar) terms, the PVDR should not include any allowance for inflation. If current dollar costs and benefits are specified, the PVDR must include the anticipated inflation rate.

The base year is usually the first year in which investments are made, although any base year can be specified in the analysis. The sum of the discounted cash flows for all years of analysis provides a measure of the benefits.

Table 4-1 illustrates a DCF analysis for a twenty-year timeframe based on the example in the "Timeframe Bandits" text box. By examining the 0% PVDR (undiscounted) columns it can be seen that Projects A and B have net cash flows of $200 and $250, respectively, indicating that B is more desirable. However, at the OMB-mandated 7% PVDR, Project A has a higher net present value than B — $59 versus $14.4 — indicating that A is indeed preferable if the future payments are worth 7% less per year.

The net benefits in each year can also be used to compute the IRR, as indicated at the bottom of Table 4-1. Note that the higher IRR for A (15.1% versus 7.75% for B) indicates that Project A is preferred.

Table 4-1 also illustrates the relationship between DCF and IRR. Note the right most columns under Project A and Project B. These show discounted cash flows for each year using the IRRs for A and B as a present value discount rate. The sum of each of these columns (net present value—NPV) is $0. This is not a coincidence – it illustrates that the IRR is computed by adjusting the PVDR until the NPV is zero.

Theoretical Basis: The formula for DCF depends on whether the discounting is **continuous** or **discrete**. For the continuous form, the formula is:

$$DCF = Fe^{-rt}$$

Where:

e = the base of natural logarithms

r = the PVDR

t = the number of periods (usually years)

F = future benefit or cost.

For discrete discounting starting at the beginning of the time period, the formula is:

$$DCF = F(1+r)^{-t}$$

For discrete discounting using the middle of the time period, the formula is:

$$DCF = F/\,(1+r)^{(t+0.5)}$$

The IRR is typically computed using the above formula and iteratively solving for the r that yields a zero NPV.

Table 4-1
Discounted Cash Flows (DCF) and Internal Rates of Return (IRR)

			PROJECT A			PROJECT B			
Year	Benefit	Cost	DCF at 0% PVDR	DCF at 7% PVDR	DCF at 15.1% PVDR	Cost	DCF at 0% PVDR	DCF at 7% PVDR	DCF at 7.75% PVDR
0	0	-100	-100	-96.7	-93.2	-250	-250	-241.7	-240.8
1	30	-10	20	18.1	16.2	-5	25	22.6	22.4
2	30	-10	20	16.9	14.1	-5	25	21.1	20.7
3	30	-10	20	15.8	12.2	-5	25	19.7	19.2
4	30	-10	20	14.8	10.6	-5	25	18.4	17.9
5	30	-10	20	13.8	9.2	-5	25	17.2	16.6
6	30	-10	20	12.9	8.0	-5	25	16.1	15.4
7	30	-10	20	12.0	7.0	-5	25	15.1	14.3
8	30	-10	20	11.3	6.1	-5	25	14.1	13.3
9	30	-10	20	10.5	5.3	-5	25	13.1	12.3
10	30	-110	-80	-39.3	-18.3	-5	25	12.3	11.4
11	30	-10	20	9.2	4.0	-5	25	11.5	10.6
12	30	-10	20	8.6	3.4	-5	25	10.7	9.8
13	30	-10	20	8.0	3.0	-5	25	10.0	9.1
14	30	-10	20	7.5	2.6	-5	25	9.4	8.5
15	30	-10	20	7.0	2.3	-5	25	8.8	7.9
16	30	-10	20	6.5	2.0	-5	25	8.2	7.3
17	30	-10	20	6.1	1.7	-5	25	7.7	6.8
18	30	-10	20	5.7	1.5	-5	25	7.2	6.3
19	30	-10	20	5.3	1.3	-5	25	6.7	5.8
20	30	-10	20	5.0	1.1	-5	25	6.2	5.4
Net Present Value		-400	200	59.0	0.0	-350	250	14.4	0.0
Int. Rate of Return				15.10%				7.75%	

Common Applications: IRR and DCF are used in economic comparisons of projects or policies of all types. In these analyses, the initial year's cash flow is negative, reflecting the original investment. In latter years, the benefits of the investment usually yield positive cash flows. Both methods are commonly used when financial considerations are the deciding factor in choosing among competing alternatives which accomplish similar objectives.

Strengths and Limitations: Both DCF and IRR are of greatest use in comparing investments with complicated cash flows and different project lives. However, neither method includes considerations of budget limitations. For example, limitations on available funds might preclude an option which has a higher IRR or NPV.

CHOOSING A DISCOUNT RATE: IN THE EYE OF THE BEHOLDER

Academics and policy makers alike debate over what ***discount rate*** *to use in various situations. Although some academics argue that a single rate should be applied in all circumstances, the current consensus is that the appropriate rate depends on the perspective of those who are being affected by a policy decision. That is, the appropriate discount rate may vary based on the issue and impacted population.*

Consumers face a wide range of situations based on ***socioeconomic status*** *and other characteristics. For example, being an older low-income renter—with a limited lifespan and little economic benefit from reduced energy charges—can increase the personal discount rate for energy-saving purchases by up to nearly 100 percent, implying a one-year payback period. Consumers face* ***uncertainty*** *about being able to retain investment benefits compared to more certain costs. Also, as investments take up a larger share of income, consumers become more* ***risk averse*** *about potential losses. Consumers generally are not regular participants in the fluid financial markets, thereby limiting their access to ready credit. Some studies have found that people typically divide their budget to save for future needs at a different discount rate than the rate that they use for purchases. This situation has led to the dichotomy where some analysts advocate using the "savings account" rate while others push a higher "credit card" rate for consumers.*

Businesses have more ready access to the financial markets, and as a result their discount rates are much more easily estimated. However, two issues arise when assessing the private sector's discount rate. First is the ***risk*** *premium level that is inherent in every investment decision. Firms often limit their risk exposure by compressing the expected payback period—frequently to as short as three years, implying a 35 percent discount rate. Second is the impact of corporate and income taxes. U.S. corporations face* ***marginal tax rates*** *in excess of 35 percent; this acts as a "wedge" between the* ***cost of capital*** *reported in the financial markets, which is "after tax" and the true cost faced by managers. For example, the allowed* ***rate of return*** *to shareholders for* ***public utilities*** *is about 10 percent including* ***inflation****; however, the corporate "before tax" discount rate can exceed 15 percent.*

Government infrastructure projects frequently displace private investment, either as direct replacements, as in the case of water systems, or by drawing capital out of the financial markets through taxes or borrowing. In either case, the appropriate discount rate is generally thought to be equivalent to the private sector rate. This rate equals the expected return on ***marginal*** *projects that would have been chosen if the capital was made available. It is important to note that these projects should have <u>an equivalent level of risk</u> to that of the government investment. For example, the rate for a water project should match that of private public utilities, not of a speculative gold mine.*

Social policy discount rates have been the primary focus of recent debate. Several different approaches to social discounting have been proposed. The social rate of time preference is based on using a risk-free rate as revealed in the marketplace. The indicator most often used in this method is the U.S. long-term Treasury Bond rate. The golden rule leads to using a rate equal to overall ***productivity*** *increases. This approach implies maintenance of a "steady state" of consumption through time. Finally, advocates of* ***intergenerational equity*** *believe the social discount rate should either decline as the time horizon increases or even be set at zero. A zero social discount rate is based on the observation that many* ***public goods*** *and natural resources do not depreciate over time, and that a person tomorrow should have the same* ***rights*** *to those resources as a person today. However, a discount rate of zero leads to people being better off in the future at the expense of people living now.*

DCF is a good method for comparing alternatives with similar timeframes. IRR is preferable in comparing projects with different investment or benefit patterns over time. IRR is also helpful in situations where it might be difficult to determine an appropriate discount rate (see "Choosing a Discount Rate: In the Eye of the Beholder" textbox).

4.3.2 ENGINEERING ECONOMICS OR LIFE-CYCLE ANALYSIS

Description: Engineering economics provides a method to account for the variable and **fixed costs** associated with operating a technology, facility or program. The costs can be described in terms of per unit of output, on an annual basis, or over the entire **life-cycle** of a technology.

The results of engineering economic analyses usually are key inputs into subsequent analysis, from financial evaluation to regional impact models. By using a common set of assumptions, the costs of various technologies can be ranked on the basis of economic **efficiency**. A ranking analysis assumes that a firm's goal is to minimize costs. However, even if this assumption does not hold, the principles of engineering economics can be used to calculate common costs for other types of analysis.

At the core of an engineering economic analysis is the method used to compare costs among project alternatives. In the case where two alternatives have the same expected economic life, a life-cycle analysis can be conducted. Life-cycle analysis involves first calculating the **discounted present value** of all costs necessary to operate the project over its lifetime. These costs can include energy, labor, material purchases, monetized environmental impacts, as well as other factors. Then the total investment costs for constructing the project are added to arrive at a total life-cycle cost.

If the project alternatives have different expected lifetimes, then a **levelized annual payment** can be calculated. For example, the cost of a traditional incandescent lightbulb can be compared with the cost of a new energy-saving fluorescent light. The former might last two years, while the latter may not fail for a decade. In the analysis, the life-cycle costs for each is totaled. Then the annual payment necessary to recover the costs over the expected lifetime is estimated. This calculation is exactly the same as that for a home mortgage — it is equivalent to the annual loan repayment, including **principal** and **interest**. The annual payment is the same each year and does not vary with project usage. Variations in this approach include calculating the levelized annual rental payment that takes into account year-to-year escalation in construction costs due to inflation and other factors. Both engineering economics and life-cycle analysis can be used as a part of broader decision analytic techniques, including **cost-effectiveness, benefit-cost, least-cost planning**, and **decision**

analysis. It is important to note that the methods rely on **accounting costs**, not **opportunity costs** (i.e., engineering economic data comes from out-of-pocket expenses, not costs associated with giving up other opportunities to use the same resources). As a result, the method assumes that the resources committed to a project are being used for their highest economic value.

Data Requirements: In engineering economics, five key pieces of information or assumptions are required:

- The initial investment or "fixed" costs to acquire and install the technology, build the facility, or begin the program.
- The annual expenditures to operate and maintain the technology, facility or program.
- The expected lifetime of the technology, facility or program.
- The operating characteristics of the technology, including output at various capacity rates and expected reliability.
- The interest or **discount rate** used to determine the appropriate **rate of return** on an investment.

For example, if an initial investment of $1,000 is made, operating costs are $25 per year, the expected life is 20 years and an interest rate of 5 percent is employed, the investor would want to receive $101 per year to break-even. The annual operating or variable costs of the technology — labor, fuel, raw materials, repairs — also can be varied over the lifetime of the facility or program.

Assumptions: Several key assumptions are usually made in an engineering economic analysis, as follows:

- First, that investors attempt to recover their initial up-front costs at a constant rate over the lifetime of the technology or project.
- Second, the technologies or programs being compared will provide the same type of product or benefits. While the analysis can be adjusted somewhat for differences, it works best with a homogeneous output, such as electricity.
- Third, the life of a technology can be accurately forecasted, and that, on average, it will be retired at the end of its **economic life**. The analysis assumes that the facility or program will not provide any benefits beyond the forecasted life, so future consumers should not pay any investment costs.
- Fourth, the benefits that accrue from the project will decline over time at a steady rate. This implies that economic **depreciation** equals physical depreciation. For example, a technology with a 20-year lifetime would have

an annual five percent decline in output.

- Fifth, variable cost increases can be forecast with reasonable accuracy, and capital investment costs are known with certainty. This can be an improper assumption in some circumstances. For example, the decommissioning costs of nuclear power plants were substantially unknown at the time most of these facilities were built.

- And finally, demand for the output of the technology or the program will remain high enough to financially support its costs throughout its economic lifetime.

Strengths and Weaknesses: Engineering economics is a relatively transparent method to compare the costs of various technologies and policies. Its explicit assumptions are relatively straightforward, and its results are based on a single expected cost.

However, the implicit assumptions act to limit the analysis, especially since economic costing does not always mesh with technological performance. This is a particular problem when trying to forecast expected lifetimes and annual benefits. It is difficult to know the true expected lifetime for many technologies, especially if maintenance efforts are more or less successful than initially projected. For example, an electric fossil-fueled power plant often operates well beyond the 30-year life used to set annual cost recovery rates. As a result, consumers have paid inappropriately high rates in the early years of plant operation.

Another problem with engineering economics is that the benefits from the facility typically rise significantly over time until the point of its retirement, but the analysis generally assumes that the costs to generate those benefits stay constant or decline. For example, reconsider the technology that cost $1,000 with annual costs paid by consumers of $101 per year. If the upfront **capital** cost of the technology was to double in 10 years to $2,000, the annual costs for this plant would increase to $178 per year. If consumer **demand** was rising and the policy was to charge the true costs of the benefits gained, the technology should be priced at the higher cost which reflects the **marginal costs** of meeting the higher demand. However, under engineering economics analysis, consumers would continue to pay $101 per year, a price that does not reflect the marginal costs of the output. The solution to this problem is to use trended rate-basing or annual rental payments which start with lower initial annual costs and rise as the cost of the technology or policy increases over time. This methodology has been explored in-depth at the California Public Utilities Commission and has been used in several electric utility rate cases.

Finally, engineering economics does not allow for incorporation of other **direct impacts**, such as environmental damage, **uncertainty** or distributive issues. Any trade-offs with direct economic efficiency must be made through side calculations, such as **scenario** or **sensitivity analyses**.

4.3.3 MATHEMATICAL-PROGRAMMING MODELS

Description: Mathematical-programming techniques, such as **linear,** quadratic or **nonlinear programming**, take engineering economic analysis one step further by accounting for **profit maximization** in the technology-ranking procedure. Programming models simulate a firm's decisions based on prospective cost and production information, but ignore other aspects of human behavior, such as **risk aversion**. Through use of these models a set of technology costs can be calculated for a range of outputs, and the technology which allows for the highest profit levels can be chosen through a mathematical search process. The models essentially produce a **normative analysis** of "what should be."

Programming models follow a similar pattern to the analytical framework described in Chapter Three. They have an **objective function** whose goal is to find the largest difference between revenues and costs, so as to maximize profits. The technologies employed are described mathematically in a set of **constraint equations** that calculate how costs vary with production input levels. The model represents a **static** snapshot in which a firm might move from one technology to another because of changes in the objective function or the constraints. The model then proceeds along a series of steps:

- The first step is to define **feasible solutions** where <u>all</u> constraints are satisfied.
- The second step is find the optimal or preferred solution from among the feasible solutions (i.e., what is the highest value of the objective function). If a constraint is **binding**, one can determine the **shadow value** or **opportunity cost** associated with relaxing the constraint by calculating how the objective function changes when that constraint is slightly relaxed.

Common Applications: Different types of mathematical-programming models have been constructed to assess the cost and production structure of various industries, including petroleum production and refining, and the agricultural sector. These models generally fall into two categories:

- *Linear-programming models* find the maximum feasible solution for a linear objective function in the face of linear constraints. This simplicity allows linear-programming models to use large data sets and derive faster solutions for large problems. However, linearity can impose restrictive **assumptions** about the type and form of economic phenomena being modeled.

- *Nonlinear-programming models*, such as *quadratic programming* or *positive mathematical programming (PMP),* use nonlinear constraints and objective functions that allow for more flexible modelling (e.g., price sensitive product demand) of economic phenomena.

Common Applications: Mathematical-programming models have been used to evaluate the economics of just about every industry. Some of the most common uses are for farming operations, petroleum refineries, airline scheduling, and industrial plant management.

Assumptions: Programming models are built on a number of different key assumptions, including:

- **Short-run** cost minimization equals profit maximization. As a result, within the appropriate constraints the models should arrive at the same solution whether they maximize the **revenue** function or minimize the cost function.

- Technology costs are well understood and can be specified with a high degree of certainty.

- Input units are divisible down to a sufficiently small amount.

- For linear and quadratic programming, the constraint equations are linear (i.e., the input factors are only multiplied by a constant and added up). This implies that the use of an input is *proportional* to the output that uses it, and that total input use is *additive* across all outputs.

- In the case of linear programming, the objective function implies that demand is perfectly "**inelastic**" or is nonresponsive to changes in product prices. Quadratic and nonlinear models can incorporate demand responsiveness but at the expense of computational ease.

Strengths and Weaknesses: Mathematical programming provides a transparent method to calculate the most efficient way to achieve the maximum benefits given a set of production technologies and resource constraints. The objective function and constraint equations are relatively straight forward, although models for large problems can be enormous due to the number of constraints.

The primary problem with a programming model — particularly linear and quadratic formulations — is that it usually represents **static**, short-term specifications of a problem. That is, all technologies must be included explicitly so that accounting for technological innovations is problematic. In other words, the models focus on the short term and assume that policy changes will not create feedback into demand and supply prices beyond the simple modelling framework. Expanding the model beyond a single operation also is difficult because it must account for the differences between firms by adding constraint equations. For example, two farms may have identical crops and may face identical prices for water, labor and equipment, but they produce different amounts of those crops. The modeler might then add another constraint for soil type which explains this difference. If a third farm is added which differs for another reason, yet another constraint must be added. The **calibration** process for these models, where results are compared to actual conditions, can lead to elaborate constraint conditions which may not be fully justified by the analysis.

A related problem is that the transition from one technology to another may lead to large, discrete "jumps" in the results, implying that firms shift *en masse* from one production process to another when costs change slightly. This behavior does not mesh with the usual observation that firms use a number of different input combinations for the same type of output.

4.3.4 STATISTICAL AND ECONOMETRIC ANALYSIS

Description: Statistics is the analysis of how real-world or **empirical** events and trends relate to each other given that a certain amount of **random** chance will intervene. Statistics relies on **probability theory** to develop measures of the *most likely* explanation of what causes certain events. **Econometrics** is the application of mathematical and statistical methods to empirical **economic** data. The result of this analysis is a **positive** or "what is" description of current and past behavioral patterns related to **supply** and demand. Econometrics examines how differences in certain conditions, such as prices, local attributes, or other factors, can lead to alternative paths of consumption or production. These behavioral and technological relationships can then be used to estimate changes resulting from policy initiatives. Likewise, uncertainty about past performance can be summarized from the statistical results and used in **sensitivity testing**.

An econometric analysis is composed of a mathematical representation which embodies a set of assumptions derived from a theoretical model. The model includes a dependent variable, which is the data the model tries to explain; independent or explanatory variables; and **parameters** that specify the mathematical relationship between the dependent and independent variables. Based on this model a **regression** is done to determine how well the model fits actual data. Along with the parameter estimates, the regression produces error estimates that can be used to construct **confidence intervals** that show a possible range for the parameters with a given probability.

Assumptions: Statistical analysis can be conducted over a spatial dimension using cross-sectional data; a temporal dimension using **time series**; or both dimensions using **pooled time series**:

- In cross-sectional analysis, the relevant variables (e.g., available technologies and products) are held essentially constant because only the ones currently in use are studied (i.e., no innovation is allowed). Cross-sectional analysis produces estimates without any time dimension.
- Time series analysis, on the other hand, can estimate how conditions (e.g., preferences or technology choices) change over time and assesses the importance of different factors in this transformation. Likewise, time series analysis can estimate both *short-term* and ***long-term*** impacts.

Econometric demand estimates rely on consumer preference or **utility assumptions**. Because the analysis is of aggregated demand, the underlying assumption is that all of the relevant consumers have the same sort of **utility** or **preference functions**, and that they are all trying to achieve maximum satisfaction given their budget constraint and trade-offs with preferences for other goods. *Supply estimates* assume that firms are **profit maximizing**, and that their production process can be represented as a quasi-technology by a mathematical equation. Again, the mathematical representation can impose additional assumptions about how production inputs relate to each other and the output rate.

Data Requirements: The first requirement in statistical analysis is that the data have a sufficient number of observations and variation to develop a **statistically valid** model. The second requirement is that the explanatory variables meet the needs of the relevant theory underlying the model.

Generally in economics either the quantity demanded or supplied or a cost function are estimated. The explanatory variables for these behavioral and technological relationships might include:

- Prices or quantities for the goods and services in question.
- Prices for **substitute** or **complementary** goods and services.
- Prices for inputs to the production process in the case of the supply or cost functions.
- Physical attributes, such as climate or soil type.
- Technological attributes, such as age of facilities, type of equipment or degree of adoption.
- Institutional and social attributes, such as regulatory requirements, exchange mechanisms, demographics or cultural factors.

Strengths and Weaknesses: Statistical analysis has advantages over other **empirical** analytical methods in that it combines data from many observations (e.g., different consumers or producers) and can be used to make generalizations to a large population. Econometrics is the most common technique used to estimate demand for goods and services. Econometric analysis can span several technological applications, including ones which are no longer in place. The econometric analysis also includes behavioral responses that might affect the use of a technology under different conditions, an effect ignored in **mathematical programming.** The advantage of this approach is that econometrics can capture conditions that lead to the development of new technologies that are currently unknown.

Statistics and econometrics suffer from several drawbacks as well. First, it relies on rather restrictive mathematical assumptions, both in the methodology and in the model specifications. Unfortunately, it is quite difficult to test for when these assumptions are violated or even which model is most appropriate. Second, the **parameter** estimates may be **biased** or incorrect for a number of reasons, including:

- **Omitted variables**, that might contain explanatory information which is instead erroneously captured by included variables in the model.
- **Serial correlation**, in which successive observations over time are explained by the previous observation.
- **Heteroskedasticity**, in which the error for estimation around a predicted value grows with the size of the value.
- **Multicollinearity**, in which two explanatory variables are too highly correlated to distinguish how much each separate variable is influencing the outcome.

Third, the model may not be adequately identified to distinguish the effect the analyst is trying to assess. This is particularly a problem in separating demand and supply effects, since price influences both the quantity consumed and produced in opposite ways. Analyses that show little or no response to price frequently have this problem. It should be pointed out that, in most cases, standard statistical tests can be used to measure whether or not problems exist in a given econometric analysis.

Fourth, **confidence intervals** are often misinterpreted from statistical studies. These do <u>not</u> imply that an analyst is 90 percent confident that the forecast is correct. Rather a confidence interval states that given the estimation methodology and the historic population, 9 out of 10 estimates done with this approach would result in the same forecast.

4.3.5 ACCOUNTING OR BUSINESS COST ANALYSIS

Description: Accounting analysis focuses on the balance sheet of an industry affected by a policy proposal. Used in combination with an engineering economic analysis, this method evaluates the impacts of changing costs on firm profitability. Accounting analysis relies on **case studies** to develop results that might be extrapolated to similar types of firms.

Data Requirements: Relatively complete financial information for either a firm or an industry is necessary for accounting analysis. Usually the most difficult information to collect is revenues for privately held firms or for individual plants of publicly held companies. Surveys and business databases, such as the one compiled by Dun and Bradstreet, are the usual information sources.

Strengths and Weaknesses: The most obvious strength of accounting analysis is that it can provide a real-world case study of how a policy might affect businesses in the short term. It has four major drawbacks:

DIRECTLY INDUCING INDIRECT IMPACTS

Companies frequently tout the economic benefits of new plant openings. For example, a freshly-located computer software facility may support 100 jobs with a payroll of $3 million, which in turn brings another 250 jobs to the community and creates an additional $10 million in increased business activity. How do analysts derive such estimates?

Employment forecasts generally rely on the principles of general equilibrium analysis — that significant economic activity in one market will affect another interrelated market. In the case of a new software facility, the demand for labor increases locally, which in turn causes total income to rise, which then ***induces*** *more purchases by the newly employed labor force at local retail outlets. Store managers respond by hiring more clerks to serve the additional customers. These new store clerks also spend their* ***wages****. This spending loop is called the* ***"multiplier effect"*** *— essentially the impact an additional dollar has as it travels through the economy. Multipliers range from 1.2 to 2.5 additional jobs created for every one new job directly created.*

In addition to the ***direct*** *multiplier effects, the facility has an* ***indirect*** *influence on the local economy by increasing demands for the locally produced goods and services which contribute to the plant's output. For example, an automobile parts supplier may expand to service a new automobile manufacturing plant. The added jobs at the parts supplier is an indirect effect of the factory. These new jobs then lead to additional induced employment, like those impacts described above.*

- First, extrapolating the results of accounting analyses to other firms or industries is highly questionable due to the disparities between situations. This danger exists for any type of **anecdotal analysis**.
- Second, in the case of surveys, firms or individuals might give biased responses that they believe will best further their own goals, including protecting the status quo.
- Third, the analysis does not allow for any accommodating responses by the firm's managers. Accounting analysis relies on an extremely **static** assumption that the firm is unable to respond in any manner to higher costs other than to absorb those costs or close shop. While in the case of certain types of small businesses this assumption may be appropriate, for large businesses this supposition may not reflect reality. The business situation is never static, and managers must make decisions which can significantly affect the "bottom line" regardless of what policies are adopted.
- Finally, and perhaps most importantly, there is not necessarily any relationship in the short run between accounting performance and economic viability.

4.3.6 REGIONAL ECONOMIC IMPACT ASSESSMENT

Regional economic impact assessments are perhaps the most widely used analytical technique employed by environmental policy makers. Regional impact assessments seek to determine the region-specific implications of particular environmental policies. In general, this method focuses on equity-related changes as opposed to efficiency-related changes. That is, regional models tend to measure the distribution of economic impacts, rather than changes in overall economic efficiency.

Regional impact models are used to identify the economic costs and benefits of a policy option. However, in employing these models it is important to investigate how costs imposed on one economic sector may impact another sector (i.e., **partial equilibrium**). For example, job loss in one industry may be offset by increased hiring by other businesses.

There are three basic types of regional impact assessment methods, as follows:

(1) Static Simple Equilibrium Models.

(2) Input-Output Models.

(3) General Equilibrium Models.

The details of these models are described below.

4.3.7 STATIC SIMPLE EQUILIBRIUM MODEL

Static simple equilibrium models, more commonly known in the economic literature as **partial equilibrium** models, assume that the effects of a change in supply or demand are limited to the impacted economic sector. In other words, the initial changes in supply and demand from a policy initiative dominate the analytic results. These are known as **direct economic impacts**. The analysis draws on assumptions and empirical data that measure the responsiveness of supply and demand to changes in prices — or **elasticities** — within the given sector. The assumption is that the participants in the sector make short-term ("**static**") decisions that are consistent with long-term ("**dynamic**") conditions.

A second step can be easily incorporated into partial equilibrium analysis to account for **indirect economic impacts** in secondary-related sectors. In this step, economic impact **multipliers** drawn from larger regional impact analyses are applied to the model.

Strengths and Weaknesses: Where policy effects are localized (e.g., in a small farming community) a **case study** approach is probably more appropriate than use of a more elaborate model, since a large regional analysis would not capture small effects. In most cases under the partial equilibrium assumption, the results from **mathematical programming**, engineering economics, or **econometrics** can be directly transferred to the analytic decision making methods described in Chapter Five. Region-wide **induced impacts** are better addressed with regional **general equilibrium** models.

4.3.8 INPUT-OUTPUT MODELS

Input-output (I/O) models use disaggregated data on industrial and commercial economic activity at a specified geographic level to project changes in spending, income and employment in an area's principal **business sectors**. The relevant data can be related to a system of interindustry transactions — the input-output accounts — which trace the flows of dollar expenditures from sector to sector as goods are produced and services are provided. Estimates of demand changes, both positive and negative, for sectoral output as a result of the policy changes are developed and applied to the input-output system to produce projections of **direct, indirect** and **induced** changes in regional output, employment, income and value added.

Common Applications: Examples of I/O models include the U.S. Forest Service's *ImpactPlanning (IMPLAN),* the U.S. Department of Commerce's Regional Impact-Output Modeling System *(RIMS II),* and the California Department of Water Resources' *State 512-sector I-O* model used to develop forecasts in *Bulletin 160.* The **multipliers** from these models often can be used in **partial**

equilibrium studies without having to run the entire model. Also certain portions of the input data provide a framework for **general equilibrium** models.

Strengths and Weaknesses: Input-output models are the simplest method to evaluate broad policy-induced economic impacts. Input-output models are particularly appropriate when the affected economy is relatively uncomplicated, with a few sectors and assets being employed in a fairly narrow manner (e.g., when most labor is employed on farms or in mining, then input-output is an appropriate analytic tool). For example, I-O can accurately portray changes in smaller California regions such as the Sacramento Valley. These regional economies usually have **marginal** and **average productivity** of assets that are relatively close and that change slowly over time.

CARM: WORKS LIKE A CHARM?

The California Agricultural Resources Model (CARM) is a nonlinear mathematical programming model that analyzes changes in statewide crop production technology, com-modity demand and resource supply. The model was first developed by Dr. Richard Howitt, of the University of California, Davis. A primary assumption of CARM is that farmers make ***profit-maximizing*** *decisions over a* ***linear production function*** *subject to a series of* ***constraints*** *in a single-year period. CARM focuses only on farm-level impacts, and stops its analysis at the farmgate. CARM's production functions are composed of* land, surface water, groundwater, fixed **capital**, and other variable input costs.

While input-output analysis is a common approach for regional impact assessments, it has several limitations. Input-output analysis is most useful to predict very short-run economic adjustments — it will not capture long-run adjustments to changes in relative prices. Because it assumes production is inflexible, input-output analysis typically overstates economic impacts from a policy change. While input-output analysis can provide useful insights into the short-term impacts of policies, this method has several limitations for long-term forecasts, as follows:

- Input-output analysis assumes fixed-proportion production technologies. A fixed-proportion production technology implies that it is impossible for a firm or industry to substitute across inputs. This assumption has several important implications for regional economic analysis, including:

1. Production does not adjust to relative price changes. For example, a farm with fixed-proportion production could not substitute efficiency-improving irrigation equipment for water if the cost of water substantially increased.

2. Production relationships are unrelated to output levels. This is contrary to experience. Some inputs, such as accounting services, increase at a decreasing rate as output grows, while other inputs, such as fuel, typically grow at an increasing rate as output grows. This limitation is most relevant to policies

that engender large production changes.

3. Technological change and economic restructuring do not occur. Input-output analysis assumes that production relationships remain unchanged through time. Thus, the ability of input-output analysis to accurately predict future economic adjustments is very limited. The potential error in input-output estimates increases as the time horizon of the study increases.

4. Input-output analysis assumes that regional demands for **intermediate** and **final goods** are unrelated to time. As a result, economic restructuring across regions is assumed not to occur.

- The production relationships described by input-output models are often derived from data originally developed as early as 1977, updated to 1982, and then again updated to 1989. However, the model's fundamental production relationships and trade patterns may reflect the economy as it was in 1977.

- Input-output analysis assumes that supply **constraints** do not limit potential economic expansion. That is, there is always additional labor and materials with which to increase output. Likewise, economic expansion in an input-output model does not affect prices for inputs, such as labor or fuel, nor does it draw labor and resources from other sectors of the economy. The implication is that all increases in regional output are net increases to the economy as a whole and all decreases are net decreases to the economy as a whole. In reality, regional increases or decreases in production may simply be transfers of economic resources from one region to another.

4.3.9 GENERAL EQUILIBRIUM REGIONAL MODELS

General equilibrium models better account for input supply constraints and regional transfers than input-output models. A computable general equilibrium (CGE) model is a **mathematical programming** description of a "textbook" economy. The model traces the impacts of various policy choices as they ripple through a regional economy. This representation of the economy includes:

- **Utility-maximizing** consumers (i.e., consumers generally act to gain the maximum satisfaction) whose decisions determine the demand for goods and supplies of labor in a region.

- **Profit-maximizing** producers (i.e., businesses generally focus on the "bottom line") whose decisions determine the supply of goods and demand for primary input factors (e.g., labor, financing, equipment, land) in a region.

- **Government** which collects taxes and provides income **transfers** and **subsidies**, and provides public services within a region.

The CGE framework accounts for interregional trade flows and specifies production technology parameters and market-clearing conditions to determine relative prices, sectoral input factor demand and output, value added through production, government receipts, and household income for the regional economy.

Common Applications: CGE models have been used by international development organizations, such as the World Bank, to forecast policy impacts in

EQUILIBRIUM ANALYSIS: PARTIAL VERSUS GENERAL

Economic analysis requires a key assumption about the region being examined to solve for how changes in costs or prices will affect the demand or supply of a good. This assumption is about the type of ***equilibrium*** *at which demand and supply will settle. The simplest approach, called* ***partial equilibrium****, assumes that most economic sectors are fixed except for the change that the economist is analyzing. For example, if tire producers increase tire prices because labor costs rise, the analysis may exclusively focus on the tire market, assuming that consumers' income remains the same; that the demand for automobiles and gasoline are unchanged; and that the producers' demand for rubber is not altered. The tire market is examined in isolation from all other markets. Partial equilibrium analysis can encompass changes in several sectors, but generally no more than a handful.*

The alternative approach is called ***general equilibrium*** *where the impacts on all affected markets are considered and influence each other. In the tire market example, increased labor wages may lead to a growth in demand for tires, but higher tire prices may both discourage purchases of new cars and lead to lower demands for other goods as well. This latter effect can act to decrease other workers' incomes and consumers' spending in general, and demand for tires falls as a result of aggregate income reductions combined with higher prices. General equilibrium analysis is more complex than partial analysis because it must represent a larger economic segment.*

Partial equilibrium analysis is appropriate if the market being investigated is a small segment of the overall economy and its linkages with other markets do not have strong feedback effects. For example, cleaning up a single streambed in a large city is unlikely to create large effects in other markets that influence the net benefits of the project. General equilibrium analysis is more appropriate in settings where the effects of a policy can be widespread across the region. For example, to fully understand broad air quality rules that affect many industries may require the use of general equilibrium analysis. There are different degrees of equilibrium analysis that are appropriate in different settings, and care must be taken to decide if the scale of analysis will capture the effects of concern.

developing countries. In the U.S., various forms of CGE models have been developed to examine trade, energy, and environmental policies. Most recently, the South Coast Air Quality Management District used a CGE-type model to evaluate its regulatory initiatives.

The Regional Economic Modeling, Inc. EDFS Model, better known as REMI, is a derivative of the CGE approach. REMI utilizes general economic theory, combined with up-to-date national and state-specific data, to estimate the regional implications of public policies. Essentially, the REMI model relies on long-run historical relationships between key variables to predict future economic patterns. The South Coast Air Quality Management District, as well as other regional air quality authorities, use REMI to estimate the economic implications of their environmental rules.

Strengths and Weaknesses: CGE models provide the most complete representation of how an economy theoretically operates. The advantage of using a CGE approach is that it can better identify when an impact may lead to a counterintuitive outcome. CGE models do not completely capture the adjustment costs or market frictions associated with policy-induced production changes for two primary reasons. First, the model acts as if producers are presented with potential costs and productivity implications before making their production decisions and *allows them to respond as though they know the outcome with certainty*. In reality, producers will choose a strategy without complete information related to the risks of a particular approach, produce their good or service, and be subjected to whatever are the resulting productivity changes and costs.

Second, CGE models are usually ***static***, rather than ***dynamic***, in structure. What this implies is that consumers and businesses in the model are assumed to be ***myopic*** — they expect the future to be just like today. This approach fails to account for how consumers and businesses act on expectations about the future. For example, businesses may ask for higher prices today because they expect prices to be even higher tomorrow.

CGE models also exclude legal and institutional factors, including **transaction** costs and issues of uncertainty. For example, the models assume all markets clear perfectly, including the labor market (i.e., full employment is possible). By ignoring these variables, the models imply that the same outcomes will result no matter what are the initial rules and organizational relationships.