

# COST-BENEFIT ANALYSIS CASES AND MATERIALS

EUSTON QUAH AND  
RAYMOND TOH



# Cost–Benefit Analysis

Cost–benefit analysis (CBA) is the systematic and analytical process of comparing benefits and costs in evaluating the desirability of a project or programme, often of a social nature and for society as a whole. CBA is fundamental to government decision-making and can be an effective tool for making informed decisions on the use of society’s scarce resources. This book highlights the main concepts and principles of cost–benefit analysis used in real life cases and actual applications. It contains rich case study material and examples of real life CBA applications with the emphasis on both physical and non-physical projects and infrastructure developments in Asia and beyond. The book also discusses techniques frequently used in applied CBA.

Part I of the book introduces the historical background and theory of CBA. Part II presents frequently discussed theories and topics in CBA, including commonly used techniques in applied CBA. Part III introduces new applications in CBA, such as the recent trend of using behavioural economics. Finally, in Part IV, case studies illustrate how CBA is applied in real life. Questions for readers and students to ponder are raised at the end of each chapter in this final section.

The scope of the case studies is more than just physical infrastructure and includes public sector social policies and programmes in health, education and social welfare, as well as the environment. The case studies, many of which have taken or are to take place in developing countries, provide a rich background to the principles of the method and are accompanied by a wealth of explanatory material. In each case, there are illustrations of how the key concepts and principles of CBA are used. The case studies analysed include:

- the Three Gorges Dam in China;
- the 2008 Beijing Olympic Games;
- the costs of global warming; and
- the Jamuna Bridge in Bangladesh.

As well as being suitable for courses in cost–benefit analysis, public finance, the environment and health economics, this book should be of interest to all public policy decision-makers and planners.

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# **Cost–Benefit Analysis**

Cases and materials

**Euston Quah and Raymond Toh**

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# Foreword

In the first edition of my Cost–Benefit Analysis (CBA) book, I introduced the method of compounding forward to a terminal value in order to expose the implicit assumption that benefits and cost are continually re-invested at the discount rate in the more commonly-used discounted present value (DPV) method of discounting future benefits and costs to the present. My recommended compounded terminal value (CTV) approach would reconcile the rankings of projects derived from the (corrected) Internal Rate of Return (IRR) criterion with those from the (corrected) DPV criterion. Needless to remark, recognition of this fact did not often percolate into the all-too-many teaching manuals on the subject.

On the other hand, I have to recognize that in all earlier editions of my CBA book, including the fifth edition with Euston Quah, our guiding concern was just how any particular change should be measured, if we were to abide by the theoretical economist’s method of basing it on the subjective valuation of the persons concerned – a counsel of perfection! Bearing in mind, however, that in any actual calculation, it is virtually impossible to realize, one has recourse to proxies. For instance, an approximate measure of consumer surplus by the area under the demand curve serves as an excellent proxy for the more fastidious Hicksian measures<sup>1</sup>.

Again, in the choice of investment criteria, we need not be overly concerned. Provided only that the ranking of alternative projects is the desideratum, simple recourse to DPV may suffice. This may be confirmed by discounting the stream of cost and benefits first by  $r$  (the average rate of time preference) alone and then by  $p$  (the actuarial rate of return on new investment) alone. Assuming  $r$  and  $p$  remain relatively unchanged over the relevant period of time, the rankings of alternative projects should be similar.

Insufficient attention is paid in CBA manuals to what may transpire to be a crucial difference between  $CV^{12}$  and  $CV^{21}$  ( $CV$  being shorthand for Compensation Variation as defined by Hicks), where  $CV^{12}$  is the most a person or group is willing to pay for a good (or for the removal of a ‘bad’) and  $CV^{21}$  is the minimum sum acceptable to forgo it. The two are not necessarily equal.

Needless to emphasize, adopting people’s subjective valuations has to be accepted as the only valid measurement in any CBA (or in any valuation exercise). Consequently, any ‘utility’ or ‘politico’ weighting has to be dismissed.

The worst offence in this regard would be to derive the weights via reference to the predilections of the policy-makers of a given country – thereby effectively subverting not only the economic checks on policies favoured, but (inadvertently) rationalizing the resulting pseudo economics to justify the country's existing policies.

It has to be noted that, notwithstanding the general acceptance of adopting people's subjective valuations as the basic data in a CBA, there can no economic rationale in determining the degree of uncertainty that has perforce been wholly arbitrary. This arbitrariness is by far the weakest aspect of a CBA since it may result in different conclusions being reached by different economists.

Finally it has to be accepted that the outcome of a CBA, even when uncertainty is ignored, is far from being (morally) compelling. Assuming a resulting figure from CBA is positive (say it were \$10 billion and ignoring, for argument's sake, the wide band of uncertainty), it can only be understood as a potential Pareto improvement of \$10 billion. What is more, this preceding adjective 'potential' does not refer to any anticipated development but simply to its being conditional on some possible future occurrence. One, moreover, that is unlikely to occur.

Thus, when the economist offers a figure, or range of figures, purporting to be derived from a CBA calculation, he has to make this clear to the political role-makers.

I have highlighted some issues in the practice of CBA. There are other equally important matters, of course, and they will be discussed in greater scope and depth in the subsequent chapters. On that note, I wish all readers a fruitful and enjoyable journey through the pages that follow.

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# Preface

Cost–Benefit Analysis is an exciting subject. It is a valuable tool available in economics to analyse proposed projects as well as post-project developments. Projects is a broad term for referring to physical projects, such as infrastructures, and also in the context of programmes and policies, such as proposed educational programmes or a health policy to reduce incidences of certain diseases.

There are already many good cost–benefit textbooks covering the principles, as well as more advanced ones covering certain aspects of cost–benefit analysis. There are also theoretical cost–benefit texts; but few provide simple illustrations of actual case studies on projects that have utilized cost–benefit analysis. Understanding the theoretical background and the welfare economics behind cost–benefit analysis is already daunting, let alone applying the principles to a real cost–benefit exercise of a proposed project.

This book aims to show real life applications behind project evaluations using cost–benefit analysis, and to highlight special topics in cost–benefit analysis which are often used in such studies. These topics may involve valuation of non-market goods, including a novel approach utilizing pair-wise comparisons to supplement valuations; value of statistical life; benefit transfer methods; discounting principles and decision criteria; and methods dealing with cost of diseases and air-pollution studies. In addition, there is a special contribution by the eminent economist, Jack Knetsch, on how recent behavioural economics can affect cost–benefit studies.

This book will appeal to students and educators of cost–benefit analysis courses at university level and all institutions of higher learning that offer the subject. It will also be very useful to research practitioners who want a quick reference to applications of cost–benefit analysis as well as to be updated with relevant techniques in cost–benefit analysis. Policy- and decision-makers will find the materials in this book very handy and relevant to their needs in understanding resource allocation decisions. The book also provides a comprehensive bibliography which should be useful for all engaged in the further study, research and applications of cost–benefit analysis.

We are very grateful to the special contributions by Professor Jack Knetsch, Dr Chia Wai Mun and Ms Christabelle Soh. We thank our research assistants, Jen Wei, Warrick Wee and J. H. A. Kamika, for their invaluable and efficient assistance in preparing this book. We thank Professor E. J. Mishan for contributing his

foreword to the book as well as his generous comments along the way. We would love to hear from our readers. Please send your comments and other suggestions to [ecsquahe@ntu.edu.sg](mailto:ecsquahe@ntu.edu.sg), for the attention of Professor Euston Quah.

Euston Quah and Raymond Toh  
Authors

**Part I**

**Background and theory of  
cost–benefit analysis**

# 1 Introduction

The idea behind cost–benefit analysis (CBA) is not a novel one. In fact, on a day-to-day basis, most people would employ, knowingly or unknowingly, decision methods similar to that of CBA – if the benefits outweigh the costs, then an action is taken, otherwise it is not. For want of a convenient term, we shall name the usual decision-making process, profit-and-loss accounting.

The question then arises – if the basic idea behind the two is similar, why then, is there a need for CBA? Why not simply allow individual decisions based on profit-and-loss accounting to organize the economy?

First, it is a matter of reference. For the most part, the area that CBA addresses is the economy of a whole country, while everyday profit-and-loss analysis only concerns individual person(s). The effects (both benefits and costs) of a person's action are not limited to the person. Yet, individual person(s) make choices based only on the benefits and costs accruing to him/her. Naturally, one can expect the social optimum to deviate from that reached by private profit-and-loss accounting. Of course, if we were to assume that markets for every good exist and that all markets are perfectly competitive, then both CBA and the sum of individual profit-and-loss calculations would yield the same outcome.

Second, as a natural extension of the differing frames of reference, what enters the computation as a benefit and what enters the computation as a cost will naturally differ between CBA and profit-and-loss accounting. Externalities, for example, will escape the individuals' profit-and-loss accounting but will be included in CBA. Transfer payments, on the other hand, provide a counter-example as they may enter profit-and-loss accounts but find no place in CBA.

Third, not only do the items to be included in each type of analysis differ, how they are to be valued also differs. In profit-and-loss accounting, items may be valued at their market prices whereas in CBA items are always valued at their opportunity cost. In the case of providing employment for an otherwise unemployed person, for example: to a firm, the wages paid to that unit of labour constitute a type of cost in the profit-and-loss accounts; in a CBA, however, the cost of employing that unit of labour is zero<sup>1</sup> since he/she would have produced nothing otherwise.

There are many textbooks providing more detailed treatment of the topic but this is not one of them; this is a case study book. Nonetheless, a brief review of the

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principles and the steps involved in conducting a CBA are presented to provide a quick refresher for seasoned practitioners and some basic grounding for readers new to the subject.

Some of the principles of CBA were highlighted in previous paragraphs. A more formal framework would be to think of the principles in terms of relevance, shadow prices, spillover effects and constraints. These correspond to the three steps in conducting a CBA, which are: deciding which items to include (relevance); computing the value of the items (shadow prices and spillover effects); and arriving at a conclusion that provides informed advice to the decision-maker (constraints).

Relevance concerns itself with the inclusion and exclusion of items. This is wholly dependent on the accounting stance, which, for CBA, is typically the whole country. Common sense would dictate that passing an item from one's left hand to one's right hand does not constitute a benefit or cost to oneself. Neither would one consider the sum of the cost of an item and the alternative use of the money as the total cost of the item. The parallels with CBA are obvious. First, a CBA must not include transfer payments as an item. Second, double-counting should be avoided. Both constitute the basic principles of CBA regarding relevance.

Shadow prices (sometimes referred to as accounting prices) constitute the true valuation of items. The true value may be thought of as the opportunity cost. Market prices are subject to much distortion either via taxation/subsidies in competitive markets or through rent-seeking behaviour in non-competitive markets and hence do not accurately reflect the opportunity costs. The principle here is to always adjust market prices to correct for distortions, if any, to obtain shadow prices that are reflective of opportunity costs.

Spillover effects may be thought of as an extension of shadow prices. Shadow prices reflect the true private value of an item. However, certain items have spillover effects (also known as externalities) that cause the social value of the item to differ from its private value. For example, in the production of certain goods, noise and smoke may be by-products that negatively affect the general population residing nearby, whose discomfort (cost) is not registered by the market. Two principles regarding spillover effects are: if present, the value of spillover effects should always be included in the CBA and such values are to be derived from the minimum compensation the parties directly affected are willing to accept.

Finally, every CBA faces a number of constraints. These constraints may or may not be political in nature but regardless of the constraint type, the CBA practitioner must work within them. As such, if the decision-maker only commissions a practitioner to find out whether a particular project yields net benefits and is thus worth funding, the practitioner can only provide information as to whether the specific project yields benefits, even if there are other more worthy projects with greater net benefits. This principle of only working within constraints necessarily means that decision-makers must take care in selecting the initial constraints to prevent situations in which a better solution is not considered due to the constraints.

Having summarized the principles of CBA, we conclude with a preview of the chapters to come.



Part I presents the background and theory of CBA and consists of this introductory chapter and the next one on the history and recent developments in CBA.

Part II deals with the theories and topics frequently discussed in CBA. Here, the reader will find discussions of the practical aspects of CBA including: valuation matters, benefit transfers, discounting issues, the value of a statistical life, the economic cost of air pollution on health and the economic cost of diseases. The relevant chapters follow the above order.

Part III introduces new applications in CBA. In this section, readers will become acquainted with the pair-wise comparison, a novel approach in valuation, as well as the lessons CBA can draw from recent developments in behavioural economics.

Part IV is a compilation of cases and materials for CBA. It provides multiple examples of CBA that cover a broad spectrum of project types from projects to improve health to those that further science. The cases reflect a geographical balance with a slight emphasis on Asia: cases are included from all five populated continents but with a higher proportion from Asia.

## 2 History and scope of cost–benefit analysis

If understood in the loose sense of weighing costs against benefits in decision-making, cost–benefit analysis (CBA) has probably existed for as long as there have been (rational) humans. In the more narrow definition as the technical subject this book is concerned with, CBA may reasonably find its formal<sup>1</sup> beginnings in the United States Flood Control Act of 1936. In this chapter, we explore the history and major developments (both in theory and application) of CBA and briefly review the more recent developments that have influenced its future direction.

### History of cost–benefit analysis

While CBA only became a formal subject of study in 1936, many of the theoretical underpinnings were developed a long time before that. Chief among them are the concepts of consumer surplus and externalities, which are the main aspects that distinguish CBA from traditional profit-and-loss accounting.

The concept of consumer surplus may be attributed to Jules Dupuit, a French civil engineer and economist who noted in 1844 (Dupuit, 1844) that users of a toll bridge enjoyed its services more than the toll they paid to use it. Dupuit named this additional enjoyment ‘relative utility’, which later became known as Alfred Marshall’s ‘consumer surplus’<sup>2</sup>.

The idea of externalities, on the other hand, was a concept developed by the English welfare economist, Arthur Cecil Pigou, in the 1920s. Pigou argued that the private and public economic product were not necessarily the same and in his *Economics of Welfare* (Pigou, 1952) published much later, he cited child labour and factory pollution, among other externalities, to illustrate his point.

The key relation of the above two concepts to CBA was that they identified how social welfare could be measured (consumer surplus) and how previously ignored factors could contribute to or subtract from it (externalities). These came into prominence when the US Flood Control Act, which mandated that proposed projects were to be evaluated to ascertain that the benefits (whomsoever they accrued to) outweighed the associated cost, was enacted in 1936. The significance of the Act lay in the fact that an exercise in measuring the net benefits to society invariably required the consideration of external effects and social welfare. This signalled a shift in policy evaluation towards the consideration of net social

benefits as opposed to a simple financial appraisal from the perspective of the producer – the norm of the time (Mishan and Quah, 2007).

However, while it became clear what aspects ought to be included, there was still a lack of consensus on how they could be valued, as the Act did not include guidelines as to how CBA and valuation studies were to be conducted.

This lack of standardized procedures and techniques was to persist for the decade following the Flood Control Act. It was not until 1946 when the US Federal Inter-Agency River Basin Committee's Subcommittee on Benefits and Costs, an inter-agency group, produced the *Proposed Practices for Economic Analysis of River Basin Projects* (1950; revised 1958) that a standardized procedure was put forth. The need for a common standard across agencies was necessary as, in the years following the enactment of the Flood Control Act, multiple agencies developed individual guidelines and procedures that appeared to do little more than justify projects that had already been decided upon. The eventual recommendations put forth by the group became more commonly known later on as the shortened *Green Book*.

While significant, the *Green Book* was still considerably incomplete in its guidelines and was later complemented by the *Budget Circular A-47* that the Bureau of Budget put forth six years later in 1952. As with the *Green Book*, the *Budget Circular A-47* was an attempt to standardize CBA across all US agencies. Of importance is the fact that the combined effect of the two publications not only served the initial inter-agency CBA standardization purposes, but it also represented a first attempt at aligning CBA practices with economic theory.

It was the latter result that caught the interest of academic circles. The late 1950s to 1970s saw the rapid development and refinement of CBA theories and techniques as economists tried to reconcile CBA practices in relation to economics. Foremost amongst the economists of this era were Eckstein, Krutilla and McKean, who, in seminal papers published in the latter part of the 1950s (Eckstein, 1958; Krutilla and Eckstein, 1958; McKean, 1958), laid the firm theoretical framework for CBA based on neoclassical welfare economics on which current CBA practices still stand. It is interesting to note that although in the 1960s and 1970s there was an especial increase in numerous publications on subjects pertaining to how non-market goods ought to be valued, most of the ideas and techniques put forth were, to a greater or lesser extent, variants of the contingent valuation method (CVM), hedonic pricing and the travel cost method. It was also during this period that these methods were first applied to the valuation of non-market goods (Davis, 1963; Ridker and Henning, 1967; Clawson and Knetsch, 1966).

While the valuation theories and techniques were still undergoing refinement in the 1970s, the criterion by which proposed projects might pass muster was well established by the 1930s. Nowadays known as the Kaldor–Hicks criterion<sup>3</sup>, it required the net money measure of gains, from a proposed project, to be positive, regardless of the effects of distribution. Otherwise known as a potential Pareto improvement, the criterion was developed after a prolonged debate amongst welfare economists about the viability of inter-personal comparisons of utility triggered by the repealing of the Corn Laws and in recognition of the impossibility

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(or at least, great unlikelihood) of achieving Pareto improvements (Mishan, 1981a,b).

At the same time that the theories and techniques of CBA were being developed, the use of it was increasingly being institutionalized. Apart from the growth in economics literature concerning CBA, the 1960s also witnessed the implementation of CBA at the national level in the US, Canada and the UK. President Lyndon Johnson of the US put into effect the planning–programme–budget system (PPBS) at the federal government level in 1965 (Hirsch, 1966). This was later reinforced by President Ronald Reagan’s Executive Order 12291 in 1980, which mandated that projects affecting the economy by more than a hundred million dollars annually had to undergo Regulatory Impact Analysis to ensure that they met the efficiency (Kaldor–Hicks) criterion (The US National Archives and Records Administration, n.d.). Thirteen years later, President Clinton issued Executive Order 12866 in 1993, which was largely similar in nature (The US National Archives and Records Administration, 1993). In Canada, aided by Sewell *et al.*’s *Guide to Benefit–Cost Analysis* (1965), the government adopted a similar PPBS in 1967. In the same year, the release of the *Government White Paper* in the UK institutionalized the CBA practice (Mishan and Quah, 2007). The institutionalization of CBA by these three countries resulted in an unprecedented increase in its application, especially with regard to proposed public projects. One of the more notable examples was the evaluation of the Third London Airport in the UK (Roskill, 1970, 1971).

On the academic front, the exploration of CBA and normative economics (Mishan, 1971, 1981b) also added a new dimension to the growing literature.

It was only a matter of time before the practice was similarly institutionalized at the international level. The OECD adopted CBA in its project evaluations in 1969; the UN did so in 1972; and the World Bank followed in 1975 (Squire and Van der Tak, 1975). The international application of CBA was first made explicit at the Earth Summit in 1992 where a consensus was reached that required public sector projects, for which countries requested funding support, to pass the CBA test. Subsequent international agreements have often included items to a similar effect.

### **Recent developments**

In more recent history, two developments that could have potentially far-reaching effects on CBA have emerged. The first is the growing number of valuation databases; the second is the development of a new branch of economics – behavioural economics.

The establishment of valuation databases, where the results of valuation studies are meticulously recorded, has thus far been limited to valuation studies of environmental goods. At present, there appear to be at least four databases of this sort, the most comprehensive being the Environmental Valuation Reference Inventory (EVRI) which was established in the late 1990s. Other databases also seem to have been established around this period or later.