

Review of the application of cost-benefit analysis

(成本效益分析)

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Introduction

- The industry has become more demanding in this modern era and global policies and environmental issues are dominating the minds of the project decision-makers.
- There exists more stringent rules and regulatory measures for project development due to cost accountability.
 - Questions - 'why we are paying so much for this and for that'
 - Stakeholders' query about the opportunity costs.
 - Cost accountability has different focus
- This talk is to provide some recent development of CBA and the extent it applies to construction projects.

Evolution of cost-benefit analysis

- First developed by a French economist Dupuit in 1884.
- 1970s - Seeley included CBA in the section of environmental economics and suggested to have building constraints or restricting factors in the application of CBA to building proposals besides the usual practice of CBA in transport proposals, river and harbour projects and flood control schemes.
- 1980s - Ferry and Brandon considered CBA as a technique to justify the spending of money on public projects. They pointed out that CBA was only valid when it was restricted to the cost comparison of those things which were capable of being quantified honestly.
- Ward and Litchfield (1980) mentioned the weighting problem in value analysis and queried about the subjectivity and objectivity in performing CBA. They questioned about the **cost of compliance** when excessive environmental and safety regulations are in place.

Evolution of cost-benefit analysis

- 1990s - Sinden & Thampapillai (1995) acknowledged the usefulness of CBA even though they once raised a concern about its application to real world issues, particularly in respect of valuing unpriced benefits and costs. However, they agreed that the systematic procedures can improve the information for decisions based on relevant economic theories and concepts.
- For this reason, they changed CBA into BCA (*benefit-cost analysis*). They also brought in the concept of constraints and accepted them as the nature of the society, echoing Seeley's first mentioning of constraints for building projects in the 1970s.

Evolution of cost-benefit analysis

- 2000s - Ashworth (2002) considered that the problem of CBA was due to the fact that the community at large had relatively unlimited wants, needs and desires when compared with the resources available to satisfy them in an economic proposition. Therefore, the difficulty in applying the technique is pricing the benefits.
- Ashworth pointed out that for public projects, it is open to manipulation of political ends.
- 2010s - Brandon and Lombardi (2011) embedded CBA concept into their evaluation of sustainability development.

Cost-benefit analysis

- a method to assess the relative **desirability of competing alternatives** in terms of their economic worth to society (Sinden & Thampapillai, 1995).
- a technique used to determine whether a **planned action** will turn out to be good or bad.
- It concerns **efficient use of resources** by estimating and totaling up the equivalent money value of the benefits and costs of a project.
- Benefits are intangible. They concern the **human well being**, and a value and a weighting is usually assign to each of the 'social' benefit such that a quantitative comparison can be made.

VIEWS ON CBA

- Mishan and Quah (2007) refers CBA as an assembly of concepts and techniques culled from mainstream economic theory, in particular from that branch known as *Welfare Economics*.
- Butter (2012) refers CBA as a quantification of the welfare effects of government policy. The *direct welfare costs* or benefits for various stakeholders could be quantified, whereas some *indirect costs and benefits* are difficult to assess. Those indirect costs and benefits are thus listed as a pro memoria (pm) because of their uncertainty.

CRITICISM ON CBA

- While CBA is commonly criticized as being judgemental and not objective enough, it calls for a systematic approach to the *direct and indirect cost* procedures in the evaluation of benefits.
- There are common error in some popular treatments of CBA and this clearly reflects the case of subjectivity. Even though the steps are clearly listed in most CBA such as Msihan and Quah (2007), Tao et al. (2011), Nas (1996), Walshe and Daffern (1990), the systematic approach does not all count for a comprehensive and errorless CBA, but it does improve the extent of availability and quality of information for decision-makers to select an optimal solution.

PROBLEMS IN THE APPLICATION OF CBA

- Non-monetized benefits and costs, e.g.
 - visual impacts, landscape and social amenities impacts, cohesion heritage or cultural impacts, human capital impacts, life and injury impacts
- Computation of components of benefits and costs
- Valuation tends to be intuitively obvious, but intuition fails to suggest methods of measurement for many of the items

PROBLEMS IN THE APPLICATION OF CBA

- Projects are frequently subject to a variety of constraints or restricting factors which require valuation.
- The constraints referred by Seeley and categorized as physical constraints, legal constraints, administrative constraints, uncertainties and distributional and budgetary constraints, are still sound for today.

Question 1

- What does cost accountability mean to you?

SCOPE OF APPLICATION

- Infrastructure projects, policy making, environmental policies, and planning
- Other areas, for example,
 - evaluating journals use in special libraries, bringing in 'utility' measures to assess the cost per use of a journal to evaluate the appropriateness of continuing subscription (Sridhar, 1988);
 - the valuation of historical buildings in identifying all relevant costs and benefits of a project, giving a financial value, discounting to present-day costs, and providing weighting in terms of their perceived importance of different heritage values (RICS, 2013); and
 - establishing a CBA framework for evaluating social (public) housing in sustainable development (RICS, 2013).
- Guidelines for CBA have already been developed by some government bodies such as Australia and Canada, and OECD (2006) also produces a more updated approach of CBA for working towards environmental policy.

Sustainability development

- Brandon and Lombardi (2011)
 - CBA sets out to measure and compare the total costs and benefits of different projects
 - A capital budgeting tool – can be used for setting up cost boundaries or cost limits
 - Appraisal technique for both public and private clients
 - Main components: project costs and project benefits
 - Two types: economic and social
 - Economic – affecting cash flow of the investor
 - Social – affecting overall welfare of the society
 - Common analytical techniques : NPV and IRR
 - Adopt CBA in evaluating sustainability

Sustainability development

- Modality for the analysis
 - Numerical
 - Spatial
 - Kinematics
 - Physical
 - Biological
 - Sensitive
 - Analytical
 - Historical
 - Communicative
 - Social
 - Economic
 - Aesthetic
 - Juridical
 - Ethical
 - credal

Valuation principles

- (1) Common unit of measurement-benefits and costs of a project have to be expressed in terms of equivalent money value at a particular time;
- (2) Valuations should represent consumers or producers actual behaviour;
- (3) Benefits are usually measured by market choices.

Cost factors

- Social cost (社會成本)

- Refer to both the private costs and any other external costs to society arising from the production or consumption of a good or service.
- opposite to private cost.
- If there is a negative externality, then social costs will be greater than private costs.
- Environmental pollution is an example of a social cost that is seldom borne completely by the polluter, thereby creating a negative externality. If there is a positive externality, then one will have higher social benefits than private benefits.
- For example, if a producer can avoid the cost of air pollution control equipment allowing the firm's production to impose costs (health or environmental degradation) on other parties that are adversely affected by the air pollution.

Cost factors

- Private cost (私人成本)
 - Cost that a producer of a good, service, or a firm pays to purchase capital equipment, hire labour, and buy materials or other inputs with actual market price. The private costs will lead to a socially efficient rate of output if there are no external costs.
 - If market prices of polluting fuels do to include values that reflect the environmental costs, these prices will be lower than the social cost.

Cost factors

- External cost
 - The difference between private costs and total costs to society of a product, service, or activity is the external cost. External cost is based on market prices, but the eventual judgment of these is to be made with shadow prices, to bring them in line with opportunity cost. (note: shadow pricing is about a value assigned to non-marketed goods when performing different types of cost-benefit analyses, for example, when performing a cost-benefit analysis on a mining operation, the lost intangible value associated with the scenic views must be priced and factored in as a cost.

Cost factors

- **Private Costs + External Costs = Social Costs**
- **If** external costs > 0 , then private costs $<$ social costs.
- **Then** society tends to:
 - - Price the good or service too low, and
 - - Produce or consume too much of the good or service.

What is the outcome?

Divergence

- divergence between private and social products (產值分離)
- divergence between private and social costs (成本分離)

Externalities

- Relate to the social evaluation of a project
- There is no transaction and therefore no market.
- Both positive externalities and negative externalities exist.
- Thus, an investment on society's welfare should be assigned appropriate values.
- However, social goods – public goods and externalities – do not by definition, have a market. Other indicators are required.
- It is suggested to use the willingness-to-pay criterion when there is no market price, so as to surrogate the supply and demand functions.

Example

- Suppose two roads, A and B, both leading to the City. Road A is flat, but narrow; and Road B is bumpy but wide. Since it is faster to drive to the City via Road A, congestion is created.
- Each driver simply consider his own time and choose to use Road A and does not bother others in affecting congestion. As a result, the congested road greatly increases the overall travelling time. Social costs > private costs.
- Up to a certain point, some drivers would choose to use Road B. Thus, congestion is slightly decreased at Road A and travelling time is a little faster.
- If congestion is created at Road B and is found more congested than Road A, then the drivers will go back to Road A. Gradually, the travelling time in taking Road A and taking Road B will be about the same.
- Pigou believes if tax is charged on Road A, it will make more drivers turn to Road B. When the travelling time is more or less the same via taking Road A and Road B, drivers will choose to take Road B. Thus using Road A will then not increase the travelling time because some drivers now turn to Road B. The congestion at Road A is therefore improved and this benefit the community. Private cost = social costs.

Private costs

Private costs	Private Benefits
Cost of land	The money made from the sale of the products
Cost of construction	
Labor costs	
Costs of running the plant when it has been built	
Transport costs of materials and completed products	

External costs

External costs	External Benefits
Waste products will cause pollution	Jobs will be created
Smoke and fumes may damage the health of residents	Other firms may move into the area to provide services to the firm producing smoke and fumes
Parkland cannot now be used by local residents	Important chemicals will be produced to benefit society

KEY ISSUES IN ASSIGNING AN ECONOMIC VALUE TO SOCIAL OBJECTIVES

- **The yes project and no project perspective**
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- Butter (2012) takes the view that null alternative or no regulation should also be considered in a CBA, as the effects of a regulation may only materialize in the long-run. Although he generally refers to government regulation and transaction costs, Butter quotes an example of the credit crisis of 2007-2010 in the financial market as a consequence of the regulation issues that the effect can be so drastic as to bring great recession. The yes project and no project perspective has been brought up in the third runway at Sydney airport (Sinden & Thampapillai, 1995) and in the final judgement of the judicial review of the HZMB case based on environmental rules (Lau, 2013).

KEY ISSUES IN ASSIGNING AN ECONOMIC VALUE TO SOCIAL OBJECTIVES

- The second-best theorem
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- Mishan and Quah (2007) point out that there is a problem of the second-best theorem. The second-best theorem is based on the concept that when one additional constraint is imposed on the welfare function, the necessary conditions that emerge from the maximizing procedure are different from those identified with the marginal-cost pricing rule. There is a tendency of choosing the second best when there are several alternatives. Usually though the first best is the ideal, but it is impossible to prove that the second best is not an optimal choice as the conditions are different. This is primarily based on an optimal allocation of resources, and a slight adjustment of the constraints will give rise to different solution. Conducting sensitivity analysis will help.
- The second-best theorem is formulated by Lipsey and Lancaster in 1956.
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KEY ISSUES IN ASSIGNING AN ECONOMIC VALUE TO SOCIAL OBJECTIVES

- **Market price against shadow price**
- Shadow pricing is about a value assigned to non-marketed goods when performing different types of cost-benefit analyses. It usually applies to external cost, and works in line with opportunity cost. External costs are most often non-monetary and problematic to quantify for comparison with monetary values, e.g. pollution. They refer to what society will likely have to pay for in some way or at some time in the future, but are not usually included in the transaction prices. External costs are based on market prices, but the eventual judgment of market prices can only be made with shadow prices.

- When consumers make purchases at market prices they reveal that the things they buy are at least as beneficial to them as the money they relinquish. Consumers will increase their consumption of any commodity up to the point where the benefit of an additional unit (marginal benefit) is equal to the marginal cost of that unit, or the market price. Therefore for any consumer buying a commodity, the marginal benefit is equal to the market price. The marginal benefit will decline with the amount consumed just as the market price has to decline to get consumers to consume a greater quantity of the commodity. A demand schedule, duly prepared to indicate the relationship between the market price and the quantity consumed, will be an useful information about marginal benefit that is needed to place a money value on an increase in consumption

KEY ISSUES IN ASSIGNING AN ECONOMIC VALUE TO SOCIAL OBJECTIVES

- **The value for gain and loss**
- to reach a conclusion as to the desirability of a project, all aspects of the project, *positive and negative*, must be expressed in terms of a common unit; that is, there must be a "bottom line". Since the most convenient common unit is money, benefits and costs are often expressed in monetary terms, and are adjusted for the [time value](#) so that all flows of benefits and flows of project costs occurring at different points of time are expressed on a common basis in terms of their "present value" (Hanley & Spash, 1993; Layard & Glaister, 1994). However, in considering the value of gain and loss in a society, it must be considered at the same time who gains and who loses on an equity basis (OECD, 2006).

KEY ISSUES IN ASSIGNING AN ECONOMIC VALUE TO SOCIAL OBJECTIVES

- **The public interest issue**
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- Public interest described in Dictionary refers to the "common well-being" or "general welfare." Public interest theory is generally grounded on public choice in regulating the market as a justification for regulatory intervention in private activity, thus limiting the exercise of private power, in pursuit of objectives valued by the community (King, 2007). The policy makers need to address the human nature in order to avoid "unintended consequences" (Fukuyama, 1999; Ho, 2012), and for this, policy makers have to address the public's foremost needs and anticipate how people may respond to specific designs in policy (Ho, 2012). In respect of policy making, Ho (2012) points out that there is a hierarchy of policy goals which some are more long-standing, more fundamental goals that can easily be hidden by immediate benefits via political expediency. The question is what the costs are to society if a policy that serves a specific goal is implemented and whether the benefits justify the costs (Ho, 2012:p.27). The issue is further compounded by human nature when people are pursuing personal interests at the same time. Therefore, the difficulty in applying the technique is pricing the benefits, and for public projects, it is open to manipulation of political ends (Ashworth, 2002).

KEY ISSUES IN ASSIGNING AN ECONOMIC VALUE TO SOCIAL OBJECTIVES

- **Accounting for risk and uncertainty**
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- Walker and Greenwood (2002) raise a question of 'where do construction risks come from'? They list five sources of construction risks: political/regulatory, technical and physical, conceptual, organizational and operational. They propose a closed system and an open system view to explain risks in the project environment. In an open system, the political and regulatory type of risks covering government, planning, contractual, pressure groups, health and safety, and environment. A project facing an environment external to the projects can be as open as the whole society. The projects that are large, of long duration, complex, of high level of subcontracting and labour-intensive tend to be inherent with risks of this kind (Walker and Greenwood, 2002). In this respect, the impact of risks is no longer design oriented or labour-oriented, and the project will be exposed to claims for compensation of all sort.
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KEY ISSUES IN ASSIGNING AN ECONOMIC VALUE TO SOCIAL OBJECTIVES

- **Population as the denominator**
- Since CBA involves social cost, for calculation purpose, there must be a value involving the number of population, which acts as a denominator for the society at large. This value makes a simple representation of the social cost. In [economics](#), a cost is an alternative that is given up as a result of a decision. When a transaction takes place, it typically involves both private costs and external costs. For a project or policy to qualify on cost-benefit grounds, its social benefits must exceed its social costs, where “Society” represents the sum of individuals (OECD, 2006). This means that a society is better off when production and consumption decisions are based on social costs that include external costs.

THE CASE EXAMPLES

- **The Hong Kong-Zhuhai-Macao Bridge (HZMB)**
- HZMB is a mega-sized infrastructure project, complex in nature and difficult to build. It connects Hong Kong Lantau Island, Guangdong Zhuhai and Macau, which would be the longest cross-sea bridge in the world when completed. It was designed to be used for 120 years and to resist 8 magnitude earthquakes. The construction of the overall facilities is estimated to be over 70 billion Hong Kong Dollars.

Background

- Nature of project
 - Cost
 - Planned completion
 - Economic benefits
 - **Work in Progress**
- **A dual 3-lane road 29.6km length with 6.7km tunnel and 2 artificial islands**
 - **RMB 76.2 billion**
 - 2016
 - e.g. Less transportation cost, less time travelling, increased transportation volume etc.
 - Inland part of Hong Kong-Zhuhai-Macao Bridge has been started for 1 year

Cost-benefits analysis

- CBA done by the transport experts.
- Benefits were seen in the reduction in distance and travelling time from Zhuhai of more than 60% to Kwai Chung and more than 80% to the Airport in Hong Kong.
- Economic benefits were also seen in traffic projection in terms of increased usage by vehicles and passengers. For economic growth, it is expected that Zhuhai and Zhongshan will achieve a GDP growth of 10-11% in 20 years.
- The project evaluation further distinguishes between different categories of direct economic costs and benefits, and includes a cost-benefit analysis over a 20-year period.

Cost-benefits analysis

- CBA carried out according to OECD standards.
- The benefits include, for example, savings in transport costs, value of time saved for travellers, induced traffic volume generated between the three territories, and value of time saved for goods on road.
- The benefits are then apportioned to the three territories taking into account the places of origin and destination of the traffic. The economic benefit is later found to be 57.8%, 32.6%, and 9.6% respectively for Hong Kong, Mainland and Macao for which apportioning of cost responsibilities is based.
- *Economic Benefits Hong Kong Mainland Macao Total Discounted Total Benefits (RMB ¥ billion) 42.8 24.1 7.1 74.0 Discounted Total Benefits Ratio 57.8% 32.6% 9.6% 100%*

Cost-benefits analysis

- It is estimated that the discounted present value of economic benefits to Hong Kong, minus the discount present value of costs contributed by Hong Kong to the project, or the net economic benefits at discounted present value (i.e. ENPV) will be around RMB ¥23 billion over the 20-year period, as compared to RMB ¥13 billion for the Mainland and RMB ¥4 billion for Macao.
- The HZMB is estimated to have an EIRR of 8.8% for Hong Kong over a 20-year period, or 12% over 40 years.

THE CASE EXAMPLES

- **CBA of the High-speed Rail Link**
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- The analysis comprises of internal cost and external cost.
 - The internal costs is the cost estimation of the project which include infrastructure costs and operating costs with a life expectancy of 50 years.
 - The external cost refers to the environmental costs based on the negative environmental effects in terms of land resumption, barrier effects, visual intrusion, noise, air pollution and contribution to global warming.
- The benefits are economic evaluation of ticket revenue, travel time savings, pollution reduction, reliability improvement and safety improvement. All costs are discounted to Net Present Value. (Tao et al. 2011)

Background

- A total length of 26 km railway network, linking Shenzhen and Guangzhou
- Connecting 16,000 kilometers of high-speed railway network in China
- Work started at the end of January 2010, and targeted to complete in 2017 (planned 2015)

Express Rail Link

Benefits

- Considering operation for 50 years, return on investment \$87 Bn, that is \$20 Bn overall
- Enhance employment, tourism, logistic, business activities
- Save travellers' time
- Connection network to cities in China
- Sustainability development for economic growth, cultural exchange, better living environment

Present status

- Delay was reported in early 2014 due to the damage of the tunnelling boring machine
- Impact on budget and programmes
- Express rail is expected to complete in 2016 and the service open in 2017.

CONCLUSION

- Find that CBA is not in its full use at the present stage even though both public clients, corporate clients and private clients now pay more attention to cost-benefit analysis
- Identify some key issues that are important to cost-benefit analysis in project planning - including the yes and no project perspective, the second-best theorem, market price against shadow price, the value for gain and loss, public interest issue, accounting for uncertainty and risk, population as the denominator.

CONCLUSION

- **CBA made simple**
- Recognize that CBA applies to evaluating investment options or scheme options. If there is only one scheme, evaluate cost and benefits with the scheme and without the scheme.
- Distinguish whether it is a public client or a private client - the clientele effect
- Decide on the value of project that requires CBA
- According to the guideline for CBA published by the European Commission in 2014, it is 50 m Euro dollars (approximately 500,000,000 HK dollars)
- Information is important for carrying out a CBA. Therefore, it requires a central information collecting point.

Question 2

- What is the project value in HK dollars you consider reasonable to carry out a CBA?

Q & A