Session/Week 5

Date March 30th – April 6th 2014

Cost-benefit analysis

Section Overview

This section is a brief introduction to the principles behind cost-benefit analysis and the type of conclusions that can be derived from it. Cost-benefit analysis is often used to assess whether a project, an action or a planned change are worth implementing compared to doing business-as-usual. More specifically, this section describes how to undertake a **financial cost-benefit analysis** from actual (financial) prices, and then how to adapt it to the viewpoint of society as a whole to derive an **economic costs-benefit analysis** (also called **social cost-benefit analysis**). This section is meant to provide a guide to critically analyse an existing cost-benefit analysis or to conduct one yourself.

Section Learning Outcomes

By the end of this section students should be able to:

- Describe the cost-benefit analysis framework
- Identify relevant stakeholders, area of interest and a timeframe
- Identify and value costs and benefits with and without project
- Describe how to structure a financial cost-benefit analysis
- Explain why economists use discounting and its consequences for consideration of future generations
- Calculate financial indicators to assess if it is worth undertaking the project
- Explain why sensitivity analysis is important and how to undertake it
- Describe the steps involved in adapting a financial cost-benefit analysis to obtain an economic cost-benefit analysis

3.1 Identification of stakeholders, area of interest and timeframe

Firstly, as for any good study, it is important to understand the context in which the assessment is to be done very carefully and thoroughly. A good understating of the study context is essential to build a cost-benefit analysis that closely matches real-life conditions and derive reliable results for informed decision-making. Failing to do so invariably leads to inaccurate and/or misleading outcomes with policy-makers and project managers taking the wrong decisions. As well as a waste of financial and human resources, consequences of these ill-informed decisions can be disastrous especially for vulnerable populations (e.g. the poor). So it is very important to do a good job from the start and get it right!

Cost-benefit analysis is a tool that helps assess whether a project is worth undertaking compared to business-as-usual. As part of the context analysis, the area of interest (project scale) and the main stakeholders should be clearly and explicitly identified. The main stakeholders often include local communities, local or national government bodies, non-governmental organisations (NGOs), donors... Participation of local stakeholders into the cost-benefit analysis process can often help identify who should be considered as impacted by the project and with what scale/scope. Including the right people form the start help raise awareness about the project. This is also helpful to calibrate the cost-benefit analysis so as to more closely match real-life conditions and derive results that leads to good decision-making.

It is also very important to consider on what timescale the change (project) occurs in order to give an appropriate timeframe to the cost-benefit analysis. Again, this can be fostered by stakeholder participation for greater assessment accuracy.

The constraints faced by stakeholders, the area of interest and the chosen timeframe impact the amounts and variation of costs and benefits across stakeholders, space and time. These constraints should also be identified as part of the context to better frame the cost-benefit analysis and potential associated risks.

3.2 Identification of "with project" and "without project" scenarios

Cost-benefit analysis is a method derived from accounting. It is used by policy-makers and project managers to assess whether an action, planned change or project is worth undertaking. This framework of analysis considers that a project is worth undertaking if the net benefits derived from it are greater than the costs. This is often undertaken separately for each stakeholder or group of stakeholders. Costs and benefits of the project are to be identified as clearly and precisely as possible. They can be broken down into as many categories as appropriate. They can be calculated from individual prices and quantities. The net benefit derived from the project is computed as follows:

With project net benefits = With project benefits -With project costs

Even if we keep doing business-as-usual, benefits and costs vary from one year to the next. The likely pattern of variation in costs and benefits (or in prices and quantities) needs to be identified. Similar to the with project scenario, the without project (or business-as-usual) net benefit can be computed as follows:

Without project net benefits = Without project benefits -Without project costs

A cost-benefit analysis compares the net benefit derived from implementing the project to the without project net benefits for each stakeholder (or each stakeholder group). That is the incremental net benefit is derived as follows:

Incremental net benefit = With project net benefits -Without project net benefits

The idea is that the project is worth undertaking if the incremental net benefit is positive, i.e. if the net benefits are greater for the with project scenario than for the without project scenario. This requires knowledge of the economic values for the costs and benefits and their timing as detailed in the following sections.

3.3 Which costs and which benefits?

Benefits and costs can be estimated from unit quantities and prices. Table 1 shows examples of quantities and unit prices that can be used to estimate costs and benefits for a range of land uses. For example, the benefits associated with are agricultural yields times the number of hectares cropped times the price per ton of crop. For a national park, benefits correspond to the number of visitors times the entry fee charged per visitor. The benefits derived from carbon storage are the number of tonnes of carbon stored times the price for each tonne of carbon.

Table 1: Example of quantities and prices to estimate costs and benefits for a range of land uses. Source: unit author.

Type of land use:	**Agriculture**	**National park or conservation area**	**Carbon storage**
Benefits			
Quantity	Crop yield (tonnes/ha) times area cropped (ha); number of animals (kg of meat)	number of visitors (country nationals, foreign tourists…)	Number of tonnes of carbon stored
Price (per quantity unit)	Market price for crops; Market price for animals; Market price for meat	entry fee per visitor; willingness to pay per visit (if no entry fee charged)	Carbon market price
Variable Costs			
Quantity	Quantity of agricultural inputs (fertiliser, water, seeds, animal feed and fodder, fuel and machinery, family	Number of park employees (park rangers, welcome centre…)	Number of trees planted

	labour, hired labour…)		
Price (per quantity unit)	Market price per unit agricultural input; labour wage	Labour wage	Price per tree seedling

Costs can be decomposed into variable costs and fixed costs. Variable costs vary with the quantity used (the higher the quantity used, the higher the cost). Fixed costs do not vary with the quantity used (e.g., insurance, building depreciation…).

The gross margin and net income can then be computed for a given year as follows:

Gross Margin = Benefits - Variable costs

Net income = Gross Margin - Fixed costs

3.4 Time Preference and discounting to compare values

Let us start with an example to help you understand what time preference is:

- If I give you $10 today, would you take the money? Yes!
- If I give you $10 but you can choose between receiving this money today or tomorrow, when would you take it? You would probably choose to have it today rather than tomorrow but waiting till tomorrow should be fine too.
- Taking this further, if you have to choose between receiving $10 today or next year, you would most probably choose to have the money today rather than next year. Now, if you could choose between receiving $10 today or $11 next year, what would you choose? And what if I offered you $20 next year instead?

Your choice on whether to take the money now or later depends on both how long you have to forego the money for and how much more money you receive to compensate for that extra waiting time. This is the same principle behind earning interest on your savings in a bank account: the bank pays you extra for leaving your money in your account to compensate for you not spending it today. In economics, the trade-off made between receiving money now and later is called a time preference.

Costs and benefits are typically incurred at different times of a project. These are not directly comparable because of inflation and time preferences. Preferences do not change significantly over the timeframe of the project by assumption. To undertake a cost-benefit analysis, all costs and benefits need to be comparable in how they are measured (price system), their currency as well as across time. Real prices can be derived from observed nominal prices by correcting for inflation. To assess a project's worth, the incremental net benefits need to be made comparable in time before they can be summed up. **Discounting** is the technique used to express equivalent economic or financial values at one given point in time. Costs and benefits occurring in the future are discounted to obtain the value they would have if they were occurring today. This value is called the present value.

The current value of future benefits and costs is computed as follows:

Present Value = Discount Factor * Value (year considered)

The discount factor directly reflects on time preferences. Several formulas exist for the discount factor. One of the most common ones is:

Discount Factor = 1/(1+r)^(t-1)

where *r* is the discount rate (social discount rate in an economic analysis) and *t* is the year. The further in the future the cost and/or benefit occurs, the less it is worth today. Also, the higher the rate of discount (*r*), the less the future is worth compared to the present. A simple way of remembering this is that the higher the rate of discount is, the quicker an amount of money loses value in time.

Economists call the preference for the present (i.e. "getting the money today") a **positive time preference**. People are said to have a **zero time-preference** when they are indifferent between getting the money in the present or in the future. If they prefer getting it in the future, they are said to have a **negative time preference**. These terms correspond to the sign of the discount rate used (e.g. positive time preference for a positive discount rate). Table 2 provides examples of present values.

Table 2: Example of timing of benefits and computation of their present value. Source: unit author.

	Year 1 (present)	**Year 2**	**Year 3**	**Year 4**
Benefit	**100**	**140**	**200**	**200**
Discount rate	10%	10%	10%	10%
Discount factor	$\frac{1}{(1+10\%)^{1-1}}$ =1	$\frac{1}{(1+10\%)^{2-1}}$ =0.9091	$\frac{1}{(1+10\%)^{3-1}}$ =0.8264	$\frac{1}{(1+10\%)^{4-1}}$ =0.7513
Present value = Discount factor * Benefit	100	127	165	150

Computation of net present values based on Table 2.

> ➢ ***Taking 10% as the social discount rate, can you recalculate the discount factor and discounted benefit detailed in the table?***
>
> ➢ ***Can you compute the present value of a benefit of 200 arising in Year 10 for r=10%? How does it compare to the present values of the same level of benefits in Year 3 and Year 4?***
>
> ➢ ***Can you compute the present values of the benefits when r decreases to 5%? Are they greater or smaller than for r=10%?***

Because of the timing of costs and benefits, the choice of a discount rate is not neutral and can influence the decision to undertake a project or not. A project that starts with high costs and have benefits later is less likely to be undertaken for a higher discount rate (giving a lower weight to later benefits than a smaller discount rate). This typically characterises environmental improvements. On the contrary, a project that starts with high benefits and have costs later (e.g. a nuclear power plant) is more likely to be undertaken for the same higher discount rate.

Choosing the appropriate rate of discount can be challenging. The rate varies across space, time and groups and is generally higher in younger and/or less developed countries. The chosen rate of interest often reflects current generation's time preferences and ignores future generation's time preferences. Future generations are not here to signal their time preference (yet!) and their influence tends to be ignored when choosing a discount rate. The more the present time has value to current generations (i.e. the higher the discount rate) the more weight is given to present generations compared to future generations.

By design, a lower discount rate assumes more intergenerational equity than a higher rate. The Stern Review on the Economics of Climate Change caused controversy at the time of its release (2006), because it considered a 1% rate of discount. 1% is a relatively low value, which gives almost equal weight to both today and tomorrow’s generations.

The social discount rate should, in theory, be determined based on current and future preferences of society as a whole for the present but also reflecting on current and future preferences for intergenerational equity. A good cost-benefit analysis should include a discussion on the consequences the chosen rate of discount rate has for future generations.

As a result of this time preference, strong identification of when benefits and costs arise is important to derive valid conclusions from a cost-benefit analysis. How to set the discount rate is a choice that needs to be justified and the consequences of this choice must be discussed. The social discount rate can be estimated through stakeholders survey. Another option would be to consider the (social) opportunity costs of capital, that is, the rate of interest that would be earned by placing the money in a bank account rather than spending it now.

3.5 Economic indicators of a project's worth

Several indicators have been developed to assess whether a project is worth implementing. The main three indicators used for assessment are the net present value (NPV), the internal rate of return (IRR) and the benefit-to-cost ratio (BCR).

The **net present value (NPV)** or net present worth is computed after all economic values have been obtained and/or estimated. The net benefit for the with-project scenario is computed by subtracting the costs from the benefits for all years. The same is then done for the without-project scenario. The net incremental benefit corresponds to the extra benefit derived from the project and is computed by subtracting the without project net benefit from the with project net benefit. The discounted value of the incremental net benefit is then computed taking year 1 as the year of reference and a 10% discount rate. The NPV of the project is the sum of the present value of the incremental net benefits across all years. These computations are illustrated in Table 3.

Table 3: Example of timing of benefits and the computation of the net present value. Source: unit author.

With Project	**Year 1 (present)**	**Year 2**	**Year 3**	**Year 4**
Benefit	100	140	200	200
Costs	300	150	0	0
Net benefit	**-200**	**-10**	**200**	**200**

Without Project

Benefit	100	90	90	90
Costs	80	80	80	80
Net benefit	**20**	**10**	**10**	**10**

Incremental net benefit	-220	-20	190	190
Present value of incremental net benefit (10% discount rate)	-220	-18	157	143
Economic Net present value (10% discount rate)	= -220 - 18 + 157 + 143 = **62**			

The project is considered worth undertaking for a NPV greater than 0 (positive) and not worth undertaking for a NPV less than 0 (negative). The NPV can be used in a financial or an economic cost-benefit analysis. This indicator does not allow comparisons across alternative projects, but only to make a decision on whether a given project is worth undertaking or not. For instance, for a project with a NPV of 100 and a project with a NPV of 1, both projects are worth undertaking. However, the project with the lowest NPV might be of more value to society as a whole despite being characterised by this lower value. This is because NPV values are not comparable for projects with different timeframes, scale and scope. To undertake a valid comparison between alternative projects, it is safer to use the next indicator, the Internal Rate of Return.

The **Internal Rate of Return (IRR)** is the discount rate at which the net present value equals zero. In other words, the maximum interest rate that can be earned from investing resources in a project. The project is accepted for an IRR equal to or greater than the opportunity cost of capital, that is the interest rate that can be earned from investing the same resources in the next best alternative project. The IRR is derived by changing the discount rate until at least one positive and one negative NPV are obtained. Going back to the previous example, NPV=62 for a 10% discount rate. If the discount rate increases to 25%, the NPV becomes -17. The IRR can be computed using the following formula:

IRR = lower discount rate + difference between rates * NPV at lower rate / sum NPV (signs ignored)

In the above example, IRR = 10% + (25%-10%) * 62 / (62+17) = 21.8%. This means that the project would lead to an interest rate of 21.8%. This is higher than the interest rates paid by banks on savings (opportunity cost of capital), so the project is worth undertaking. The IRR value is prone to measurement error but its accuracy can be improved by changing the interest rates until obtaining a positive and a negative NPV that are both close to zero. It is important to note that the internal rate of discount value is not necessarily always unique, in which case the IRR values cannot be used to decide on a project's worth.

The **benefit-to-cost ratio (BCR)** is the first indicator that has been historically adopted by project managers to assess the worth of a project. It computes the ratio obtained by dividing the present value of the benefit stream by the present value of the cost stream, discounted at the opportunity cost of capital. A project is accepted if the BCR is greater than or equal to 1. Using the same example as above, the relevant values can be computed and are summarised in Table 4. The BCR is 170% for an opportunity cost of capital of 10% and the project is considered worth undertaking.

Table 4: Example of timing of benefits and costs and computation of the benefit-to-cost ratio. Source: unit author.

With Project	**Year 1 (present)**	**Year 2**	**Year 3**	**Year 4**
Benefit	100	140	200	200
Costs	300	150	0	0
Without Project				
Benefit	100	90	90	90

Costs	80	80	80	80

Incremental net benefit	0	50	110	110
Present value of incremental net benefit (10% discount rate)	**0**	**45**	**91**	**83**
Incremental net cost	220	70	-80	-80
Present value of incremental net cost (10% discount rate)	**220**	**64**	**-66**	**-60**
Benefit-to-cost ratio	(0 + 45 + 91 + 83) / (220 + 64 - 66 - 60) = 170%			

All three indicators are complementary and when possible should be computed to assess a project's worth. In our example, all three indicators lead to conclude that the project is worth undertaking. However, these indicators do not necessarily always lead to the same conclusion, in which case a further formal discussion on whether the project is worth undertaking needs to be included with the cost-benefit analysis.

These indicators can be computed in a financial setting (ie when costs and benefits correspond to actual money flow in the economy) as well as in an economic setting (where costs and benefits correspond to the values allocated by society as a whole, which may or may not match actual prices). In the case of a financial analysis, the economic indicators of a project's worth can sometimes be referred to as "financial indicators".

3.6 Sensitivity analysis to assess risk and resilience

One of the limitations of cost-benefit analysis is that it often relies on average values for quantities, prices, costs and benefits. This means that the analysis and the economic indicators derived from it provide a good idea of whether the project is worth undertaking on average but fail to consider the viability of the project under extreme events such as droughts, floods, food crises, financial crises. This is important because extreme events are becoming more frequent as a consequence of climate change.

A sensitivity analysis aims to assess consequences on the project's economic worth for risks arising from the project itself or external forces. A good sensitivity analysis helps assess the resilience of the consequences of project implementation and its social consequences. This is particularly critical to assess whether livelihoods of already fragile populations can be sustained even under extreme events or not.

A simple way of conducting a sensitivity analysis is to identify the main quantities and/or prices that are likely to change, e.g. because of droughts, floods, changes in inputs or fluctuations in commodity prices on the world market. This can be done in consultation with the relevant stakeholders and/or based on local or international expert opinion. The average values originally used in the cost-benefit analysis are changed to the new "extreme" values and the economic indicators of a project's worth are recalculated to assess whether the project remains economically worth implementing.

If the project is worth doing on average but not under extreme events, a policy-maker might want to consider either not undertaking this project or providing some form of safety net such as an insurance scheme or subsidies for when these extreme events occur especially for projects targeting fragile populations. This decision depends on wider political considerations and needs to be discussed with the relevant stakeholders to figure out what the best applicable solution is.

Alternatively, the values of quantities and prices of inputs (raw materials, labour, minimum wage, discount rate...) can be changed to obtain "switching values" - the values for which the project becomes economically undesirable (e.g. the input value which leads to NPV=0). You can change one value at a time and/or a bundle of values. You then need to estimate whether the values under which the project becomes economically undesirable are likely to arise or not, in light of previous and future biophysical and economic patterns and by discussions with local and national stakeholders and experts. Again, depending on the results and consultation with stakeholders, you may want to abandon the project and/or introduce safety net mechanisms.

Social analysis and Environmental analysis

A good financial or economic assessment not only comprises a **cost-benefit analysis** but also a **social analysis** and an **environmental analysis** to assess the consequences of the project on the different populations (ethnicities, villages…) as well as on the environment (pollution, natural resource availability…). These are not detailed in this unit but are essential to assess accurately the success and resilience of the project considered for implementation.

3.3 Derivation of economic costs and benefits from financial values

A financial analysis is based on the financial costs and benefits to participants (individuals, firms, organisations) whereas an economic analysis is based on the costs and benefits to society as a whole. Financial costs and benefits are typically observed through market prices, user fees… In this unit, we are interested in economic values rather than financial values.

Economic values are referred to as **shadow prices,** as they are "in the shadow" of the financial values that can be observed in real-life. Economic values correspond to opportunity costs and/or willingness to pay for the goods and services considered from the point of view of society as a whole. One of the easiest ways to undertake an economic cost-benefit analysis is to first perform a financial analysis and then adjust each financial value to derive its economic equivalent.

Adjustments between financial and economic values are needed because of market price distortions that arise when markets are not perfectly competitive. The type of adjustment varies with: (i) the type of value being considered (transfer payments, traded good, non-traded tradable good, non-traded non-tradable goods), (ii) the reference adopted for measuring the costs and benefits (world or domestic price system) and (iii) the currency (domestic or foreign) in which benefits and costs are expressed.

The adjustment process outlined below leads to the shadow values required for an economic cost-benefit analysis.

Economic values can be derived or estimated from financial values in 3 steps:

Step 1 – Adjust for transfer payments (taxes and subsidies)

Step 2 – Adjust for price distortions in traded goods

Step 3 – Adjust for price distortions in non-traded goods (tradables and non-tradables).

Step 1 consists in removing **transfer payments** from the financial values, i.e. payments that corresponds to a redistribution of wealth within society. This is a step undertaken for values expressed in the *domestic price system* only. They change the financial incentives faced by an individual but not the wealth of society as a whole. Taxes and subsidies are typical examples of this kind of redistribution. This also applies to user fees that are transferred from a user to a provider within a given society.

Step 2 consists in adjusting the financial price values to remove market imperfections and distortions introduced by policies such as minimum wage or land market regulations. There are two different aspects that need to be checked upon to ensure that economic values are measured and expressed in a consistent way: the point of reference and the currency. Shadow prices are derived for the same point of reference or numéraire ("measuring unit"), e.g. using a world or a domestic price system. In the *world price system*, the opportunity costs to the country of traded goods are assumed to correspond to border prices. These opportunity costs are valued using the cif (cost, insurance, freight) for imports and the fob (free on board) for exports. In the *domestic price system*, economic values correspond to what society is willing to pay for goods and services. For both price systems, economic values can be expressed either in a foreign currency or the domestic currency. When values are expressed in different currencies, the **Shadow Exchange Rate (SER)** is used for conversion of values into one single currency for consistency.

Step 3 consists in adjusting the values of tradable but non-traded goods (i.e. good that can theoretically be traded but are not trade in practice) in the World price system. This can be done by using a **conversion factor** when financial prices are considered good estimates of opportunity costs. The conversion factor is the ratio of the shadow price to the domestic market price. It is called **standard conversion factor** when an average ratio is used. Non-tradable goods need to be valued using specific economic valuation methods in order to estimate their opportunity costs. In the domestic price system, the values of non-traded and non-tradable goods are estimated based on their opportunity costs.

Table 5 summarises the adjustments to be made depending on the price system used.

Table 5: Adjustments to derive shadow prices from financial prices. Source: unit author.

		PRICE SYSTEM	
		World	**Domestic**
SHADOW PRICES	**Traded goods**	- cif (cost, insurance, freight) - fob (free on board)	- Delete taxes and subsidies - Shadow Exchange Rate (SER)
	Non-traded goods	- Conversion Factor (CF) - Standard Conversion Factor (SCF) - Opportunity Cost (OC)	- Opportunity Cost (OC) - Correct for price distortions

The actual transformation is a bit more complex than detailed above but this should give you an idea of how to adapt a financial cost-benefit analysis into an economic cost-benefit analysis. You can refer to the recommended readings for more information on how to perform such adjustments. Because an economic cost-benefit analysis adopts the perspective as society as whole, it can be used to assess the desirability of a project from this perspective. It does not, however, reflect on incentives faced by individual stakeholders or stakeholder groups and should thus be complemented by a financial cost-benefit analysis for a thorough assessment of the proposed project.

Once transfer payment have been removed and shadow economic values of costs and benefits have been estimated, the economic indicators used for the financial analysis – i.e. the net present value, the internal rate of return and the benefit-to-cost ratio - can be derived from the perspective of society as a whole. The values may not match those of the indicators derived from the financial analysis, and may sometimes lead to contradicting conclusions. Ultimately, the decision to undertake the project or not when indicators are contradictory between the financial and economic analyses will depend on how much priority is given to actual financial flows over the value to society as a whole. It may be socially acceptable to go ahead with a development project that leads to small losses for society as a whole (negative NPV in the economic analysis) but that allows poor stakeholders to benefit from it (positive NPV in the financial analysis).

Because the values of the costs and benefits have changed, a new sensitivity analysis should be performed. The environmental and social analyses undertaken in relation to the financial cost-benefit analysis still need to be conducted undertaken as a complement to the financial and economic cost-benefit analyses.

From:

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for sustainable management of land

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