

## **Cost-effectiveness analysis (CEA)**

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# Cost-Effectiveness Analysis

# 1 Introduction

A cost–effectiveness analysis (CEA) seeks to find the best alternative activity, process, or intervention that minimises resource use to achieve a desired result. Analysts and agencies perform CEAs when the objectives of the public policy have been identified and the only remaining question is to find the least cost–option of arriving at these objectives. CEA, therefore, does not ask, nor attempts to answer, the question whether the policy is justified, in the sense that its social benefits exceed its costs.

CEA is also sometimes used as a second–best option when a full–blown CBA would be desirable, but many benefits cannot easily be monetized.

The cost effectiveness of a policy option is calculated by dividing the annualized costs of the option by physical benefit measures, such as animal or plant species recovered, tons of emissions of a given pollutant, acres of farmland preserved, kilometres of river length restored, etc.

# 2 Methodology

Like Cost–Benefit Analysis, Cost–Effectiveness Analysis can be used either to assess the expected impacts of alternative policy measures before they are implemented (ex–ante), or to assess the effectiveness of a policy measure that is already in place (ex–post). While the approach and the methods used are the same for ex–ante and ex–post CEAs, the purpose of the instrument is different. Ex–ante CEA is used up front, at an early stage in the policymaking process, to identify the path of action that promises to be most cost–effective. An ex–ante assessment will need to rely on assumptions and projections, as well as on cost and effectiveness data from different contexts, in order to anticipate the impacts of future measures.

By contrast, the ex–post CEA aims to assess whether a problem has been tackled effectively through the policy measure or project investigated. In other words, it provides a measure for the efficiency of policy implementation. To achieve this, a (counterfactual) comparison with alternative paths of actions is one possibility: with the benefit of hindsight, would there have been cheaper/more efficient ways of reaching the same target? However, this means that the actual results of one measure are compared with hypothetical results of another option, at a stage when the decision has already been taken. Therefore, it is often more informative to compare the results of the investigated policy measure or project with one of the following:

- Compliance with the original objectives specified for the measure, i.e. with (effectiveness) standards and with budget constraints (where applicable). In other words, did the measure reach its target, at the projected costs?
- This may include a comparison with ex–ante assessments of costs and effectiveness (where available). Was the measure as efficient as expected and projected?
- Costs and effects of comparable measures implemented in other countries, especially in cases where the measure was taken to meet the same legal requirement (e.g. an EU directive). This cross–country comparison may also take the form of benchmarking: Was the measure efficient by international standards?
- For policy measures that are implemented over a longer time, several ex–post analyses may be carried out in order to assess whether cost–effectiveness has increased over time.

For ex–post CEAs, a particular difficulty is to disentangle the impacts of different policy measures and changes in other relevant influences, in order to assess how much of the observed impacts can be traced back to the policy measure in question. For example, an assessment of the impact of ecological tax reform on fossil fuel consumption would also need to take account of the development of the oil price, GDP growth as an indicator for transport demand, or the effects of other policy measures such as emissions trading or pollution standards. Such effects can be assessed, for example, with the help of sectoral models or CGE–models.

### 3 Process

A CEA is a multi–step process. After defining the policy of interest, an analyst conducts a cost assessment and an effectiveness assessment for each alternative measure for implementing the policy, and then integrates these assessments into a decisional analysis. In general, CEA is most relevant when different policy measures yield the same annual effectiveness, but at different costs.

- First, carrying out a CEA requires identifying the specific policy objective—e.g. reducing river pollution by the socially optimal amount. This objective can be defined both in terms of pressures (reducing pollution levels) or in terms of impacts (achieving a certain level of environmental quality).
- Second, the analyst examines to what extent this objective is already met (distance to target), and establishes a baseline (either the status quo or a projected baseline – which should be the ‘business as usual’ or ‘do nothing’ scenario).
- Third, the analyst identifies the potential sources of pressures and impacts related to the policy objective, i.e. he describes (in physical terms) those human activities that have a negative impact on the environmental objective
- Fourth, the analyst decides which policy interventions can reasonably achieve the regulatory target (relative to a specified baseline situation). A CEA then aims to uncover which of these interventions is expected to achieve this target at the lowest cost.
- Fifth, the costs of the policy measure need to be determined. The total annualised costs for a policy measure include all marginal (i.e. not already sunk or fixed) costs—including start–up costs, program costs, capital costs, personnel costs, and opportunity costs. If the policy measure will give rise to cost savings in another policy program, then these savings should be subtracted (“netted out”) from the cost calculation. Because the existence of current investment opportunities makes current expenditures more expensive than equivalent future expenditures, all costs should be discounted to their present value by using an appropriate discount rate (typically around 3 to 4 percent). When calculating the sum of discounted costs—together considered the “life cycle cost” of a policy alternative—the analyst should pay special attention to economies and diseconomies of scale (seeing if the marginal cost of regulation increases or decreases with increasing intervention) and varying degrees of government involvement (considering whether citizens prefer laissez–faire policies).
- The sixth step is to determine the effectiveness: The analyst must carefully select appropriate measures of effectiveness. Effectiveness may be defined in terms of pressures (how many kilograms of mercury are expected to be removed, or were removed, due to the policy intervention?) or in terms of impacts (how has the fish population grown due to pollution reduction?). Which of the two is more appropriate depends on the policy objective. Due to the complexity of ecosystem interactions, determining effectiveness in terms of impacts may be considerably more difficult. Additionally, an accurate measure of effectiveness may require “weighting” of indicators, in order to reflect their relative contribution to effectiveness. For example, mercury is more toxic than arsenic, therefore with a policy that is targeted at reducing overall toxicity, a 1 kg reduction in mercury pollution will be weighted as more “effective” than an equivalent reduction in arsenic pollution.
- Finally, the cost–effectiveness of different options can be inferred. Ultimately, incremental cost–effectiveness measures the difference in costs divided by the difference in effectiveness that result from comparing one policy measure to the next most effective policy measure (or a baseline situation). An incremental cost–effectiveness ratio is expressed by  $(\text{Cost Option A} - \text{Cost Option B}) / (\text{Effectiveness of A} - \text{Effectiveness of B})$ , where A is the more effective policy measure and B is the next most effective. An “overall” cost–effective analysis simply compares each policy intervention’s cost per unit of effectiveness ( $\text{Cost Option A} / \text{Effectiveness of A}$ ). Given these ratios, the CEA is ready for policy review.

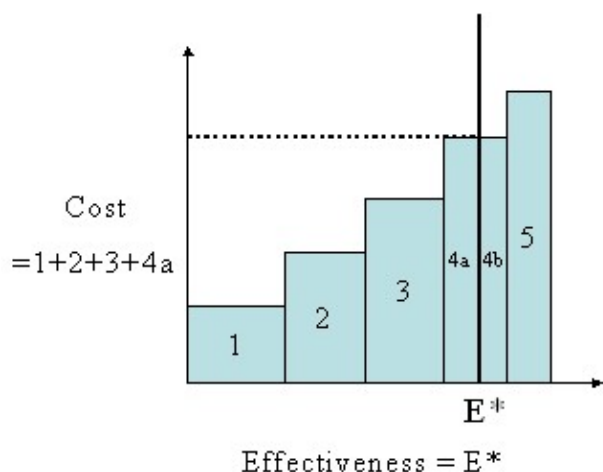
### 4 Review

## 4.1 Evaluation results

The results of a CEA can be presented in different ways. In simple cases, each option being evaluated consists of only one measure. Thus, for example, if the objective is to reduce nitrate levels in a river, the options are either to implement a tax on fertilisers, or to consult farmers on better fertilisation strategies, or to upgrade sewage treatment, or to enhance denitrification in wetlands. In this case, the policy measures investigated in the CEA can be ranked by their cost-effectiveness. The most preferable option is then the measure with the lowest cost-effectiveness ratio (least cost per unit of effectiveness). If the policy objective is clearly defined (or if the available budget is known), it is also possible to rank the measures based on how much it will cost to achieve this objective with each measure (or how much of the desired effect can be achieved with the given budget).

In many instances, however, a single measure may not be sufficient, so that a combination of different measures will make up the policy option(s) being explored: for example, a tax on nitrogen fertiliser would be complemented by training for farmers, and this would be supplemented by technical measures for nitrate retention. The best solution can be found by ranking all policy options in terms of their incremental cost-effectiveness ratio. The lowest incremental cost-effectiveness ratio indicates that policy A (the more effective measure) dominates policy B (the next most effective) in terms of cost-effectiveness. To maximise cost-effectiveness, regulators should implement policy A until its marginal cost-effectiveness is dominated by that of another policy measure. In this sense, narrowly choosing a single policy measure will rarely be the most cost-effective policy, and the preferred option will be a combination of measures. Rather, implementing a suite of policy measures such that their marginal costs are equal will yield, by definition, the most cost-effective approach. As with any policy decision, distributional considerations and value judgments will determine if the most cost-effective plan is endorsed.

The below graph depicts an optimally cost-effective, measure-by-measure approach to policy implementation. Assuming cost-effectiveness is the only decision criterion, the policymaker applies policy measures in increasing order of their cost/effectiveness ratio (i.e. measures 1, 2, 3 and partially 4), until the desired effectiveness ( $E^*$ ) is achieved.



## 4.2 Experiences

Traditionally, CEA has been used widely in medical decisionmaking and in public health. Suppose, for example, that two medical treatments or alternative public health programs were able to avoid 100 and 70 cases of an illness at the cost of €10,000 and €9500, respectively. Then the cost of effectiveness of these programs would be expressed in the cost per case avoided, which would equal to €100 and €135, respectively. Clearly, all else the same the first program would be deemed more cost-effective. This example illustrates one reason for doing a CEA—in order to choose between alternative ways of attaining the same objectives.

## Cost–effectiveness analysis (CEA)

In the context of environmental policy, CEA is applicable in those cases where the decision on environmental objectives has already been made, based on ecological or biochemical grounds (such as the ‘good ecological status’ in the Water Framework Directive [DG ECO2, 2004]), or as a result of political bargaining (e.g., in the case of the Kyoto protocol). In these cases, a CEA may help find the least–cost way of achieving the targets.[1]

There are several pieces of environmental legislation at the EU level that require some type of cost–effectiveness analysis, either ex–ante or ex–post. Table 1, based on van Asselt and Oosterhuis (2004), provides a brief overview of the directives explicitly providing for a cost–effectiveness analysis.

Table 1. Examples of CEA for European Union legislation and initiatives.

CEA type required	Regulation / Directive	Title
Ex–ante	Directive 98/69	Air pollution by emissions from motor vehicles
	Directive 2000/60	Water Framework Directive
	Directive 2000/69	Benzene and carbon monoxide in ambient air
	Directive 2001/80	Large combustion plants
	Directive 2001/81	National Emission Ceilings
	Directive 2002/30	Rules and procedures with regard to the introduction of noise–related operating restrictions at Community airports
	Directive 2002/49	Assessment and management of environmental noise
	Directive 2004/8	Cogeneration
Ex–post	Regulation 1260/1999	General provisions on the Structural Funds
	Regulation 1267/1999	Instrument for Structural Policies for Pre–Accession (ISPA)
	Directive 2001/77	Promotion of electricity produced from renewable energy sources in the internal electricity market
	Directive 2003/30	Promotion of biofuels and other renewable fuels

As long as the physical objectives of the policy are identified, CEA can be applied in many other policy or program contexts. For example, we have recently seen a CEA for a tightening of “homeland security” procedures by the US Coast Guard (OMB, 2004). Cost–effectiveness was expressed in dollars per risk point reduced (where risk signifies risk of a transportation security incident).

## 4.3 Combinations

CEA need not be a stand–alone tool for decision support. In fact, one of the drawbacks of a CEA is that the objective – the effectiveness term – is defined in one single dimension only. If different policy options differ in their performance towards secondary objectives – e.g., if a climate policy option creates co–benefits in terms of local air quality and health – these differences would not be considered in a CEA. The results of a CEA are therefore often integrated into a multi–criteria analysis (MCA) which allows for a combination of different decision criteria in different formats. While cost–effectiveness may be one the most important priorities in deciding if and how a policy objective can be met, an MCA allows comparison of e.g. co–benefit of different options, distributional impacts, sustainability, political feasibility, and competitiveness.

## 4.4 Strengths and weaknesses

Estimation of the costs of a policy within a CEA is done in a manner similar to that in a CBA. The reader is therefore referred to section 2.2.1 for a discussion of possible categories of costs of a policy. Because estimating the costs of the policy is generally perceived as easier than estimating its benefits (Moore, 1995), most economists would probably concede that CEA is somewhat easier to perform than a full CBA. Indeed, CEA and CBA can be seen as parts of a continuum of assessment tools, with CBA as the most extensive and elaborated option, and CEA as a somewhat less extensive procedure.

Analysts engaging in a CEA, however, may still have to deal with complex issues such as the choice of the discount rate, if the costs of the program are incurred in later periods, or the quantification of the effectiveness, especially where in cases where measures have more than one target objective, and perform differently for these multiple objectives. To illustrate, consider a policy that requires the use of scrubbers on power plants and other emitting plants, resulting in simultaneous reductions in emissions of nitrogen oxides and hydrocarbons (both of which are tropospheric ozone precursors). It is not straightforward to apportion the cost of installing and operating the scrubbers on the reductions in the emissions of nitrogen oxides and hydrocarbons, which is required to express the cost per ton of nitrogen oxides and per ton of hydrocarbons.

One limitation of cost-effectiveness analysis is that it does not reveal what program scale is reasonable or optimal. Another limitation is that it cannot be used to compare situations with different benefit streams, because – unlike CBA – it does not convert them to a common unit of measurement. This is particularly relevant in those cases where at least one option creates a significant co-benefit in addition to its main effect – e.g. if a wetland that was constructed for nitrate retention also adds to the protection of local biodiversity. Therefore, it is advisable to proceed from a CEA to a CBA or an MCA in those cases where (a) one or more of the compared options provides a significant co-benefit, and where (b) this co-benefit may alter the selection of the preferred option. In other words, if the compared options do not have significant costs and benefits other than those related to the primary objective, CEA is fine. In addition to this, other criteria, such as statutory requirements, enforcement problems, technological feasibility, and others may preclude selecting the least cost solution in a regulatory decision.

## 4.5 Further work

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