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Methodologies and improvement opportunities in cost-effectiveness evaluations of emission reduction measures

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Analysing cost-effectiveness of emission reduction measures is complex and various different methodologies exist

The purpose of the study carried out by Pöyry was to provide an overview of the currently available methods for assessing the cost-effectiveness of emission reduction measures in the so called effort-sharing sector. It was found that there is a variety of different methodologies that can be used to analyze the cost-effectiveness of emissions reduction measures. The methods also vary significantly between different countries, research papers and sectors. Each method has its own benefits and limitations, therefore there is no one correct method to evaluate the cost-effectiveness of an emission reduction measure. Often calculation assumptions are not described in sufficient detail, which makes it more difficult to compare different analysis results and to develop the analysis methodologies further. Having more transparency around methodologies and assumptions would enable a wider discussion and would help in developing the different methods further. In addition, Finland should make the analysis of the emission reduction measures and political mechanisms more systematic. Moreover, success of the applied measures and mechanisms should be followed-up systematically both with regards to realized emissions reductions and realized cost-effectiveness.

Research and development of cost-effectiveness calculations concerning emission reduction measures is required

The implementation of Finland’s Medium-term Climate Change Policy Plan (KAISU) commenced in 2018. The plan identifies the areas for reducing greenhouse gas emissions in the so called effort-sharing sector and outlines the measures required to meet the 2030 emission reduction objectives. The key principle has been the selection of feasible measures that are cost-effective, meaning that the costs for meeting the emission reduction objective are as low as possible. However, the basic information concerning the cost-effectiveness of both the current and planned measures is partly insufficient, and there is uncertainty concerning the cost-effectiveness estimates for emission reduction measures.

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The topic has been researched, and rough estimates of the costs related to the measures have been presented for some sectors and for some emission reduction measures. Nevertheless, more basic information is required, and commensurate comparison of the measures should be developed in order to ensure that the climate policy objectives can be met as cost-effectively as possible. The information needs related to the evaluation of the cost-effectiveness of emission reduction measures concerns, in particular, the effort-sharing sector that is not within the scope of emissions trading. Unlike emissions trading, this sector currently has no unified pricing mechanism for emissions.

This is the premise for the project “Evaluation of the cost-effectiveness of emission reduction measures”, which was implemented by Pöyry in 2019. The work is based on literature review, workshops and expert assessments.

Information obtained through the literature review was used to create a general view of the measures that are currently being applied, to highlight the best practices and to provide background information that can be used when preparing and evaluating cost-efficiency analyses. The work mainly involves the research of methodology, but it also includes a description of how analyses are ordered and carried out in various countries, in addition to which the best practices are highlighted. The work included a total of three workshops, discussing the calculation methods for determining the cost-effectiveness of emission reductions and the related assumptions, strengths and uncertainty factors. The purpose of the workshops was to discuss the examples from other countries and the possibilities to utilise them. An additional objective was to increase understanding of the interdependencies of the measures and their effect on the calculations. The workshop participants came mainly from ministries and research organisations. In the last phase of the work, recommendations and improvement opportunities concerning the development of cost-effectiveness evaluation were listed.

A final project report has been published, with the report assessing, in particular, the methods for evaluating the cost-effectiveness of emission reduction measures focusing on the effort-sharing sector. The assessment is sector-specific and includes background calculations, methods, evaluation of the cost-effectiveness of measures, cost comparison between various sectors and the allocation of costs to various parties. In addition, Pöyry prepared example calculations for all sectors. The Finnish practices have been compared with the best practices of selected countries. The objective of the report was to provide tools for the evaluation of the cost-effectiveness of emission reduction measures. This policy brief presents a summary of the key conclusions in the report.

Methods for the evaluation of cost-effectiveness

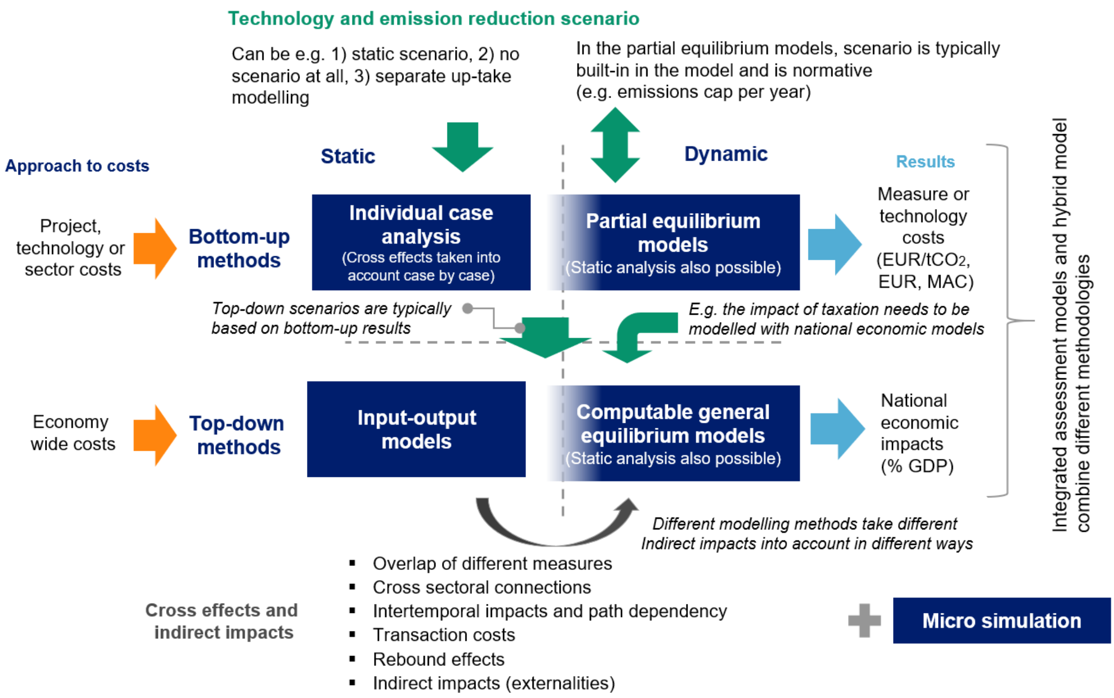
During the work, it was discovered that the reduction of greenhouse gas emissions and the related costs have been studied in various research projects, but cost-effectiveness has been researched less. The review methods and processes vary depending on the country and sector.

There are several methods that can be used for evaluating cost-effectiveness, and the applied methods vary greatly depending on the report. Each method has its own advantages and limitations, and different approaches can be used to examine a problem from various perspectives by answering different questions. For this reason, there is no single correct method for evaluating the cost-effectiveness of emission reduction measures. In addition, the analysis of cost-effectiveness is a multi-disciplinary issue requiring, for example, system thinking and deep understanding of the realms of various sectors. In some cases, understanding of biological processes is also required.

In general, the methods can be categorised as top-down (focus on costs incurred by the national economy) and bottom-up methods (focus on technology costs). Within and in addition to these main methods, there is also a great number of other methods and combinations of methods. Figure 1 presents a summary of the main analysis methods. The presented classification is partly based on the categories identified by Söderholm (2012) and Zhang & Folmer (1998) and the observations made during the work. The figure presents the various modelling methods and the interdependencies between the other parts and the selected modelling method. There are four key methods:

1. Individual case analysis, such as straightforward spreadsheet calculations
2. Partial equilibrium models, such as the TIMES models that calculate the optimal technology combination within specific limitations, for example, maximum annual CO_2 emissions
3. Input-output models
4. Computable general equilibrium models, such as the Swedish EMEC model

Figure 1 Classification of the calculation methods for cost-effectiveness



The selected approach, that is, the cost-effectiveness perspective, modelling method and scenarios, has a significant effect on the modelling or the calculation results. In bottom-up methods, the project, technology or sector-specific costs are estimated, and results are correspondingly presented as technology costs, costs of measures or costs for a specific sector. In top-down methods, the effects on the national economy are reviewed and, for this reason, the typical end-result is the change effect on the gross domestic product.

In addition, various scenarios can be reviewed by using the different modelling methods. Partial equilibrium models often have "built-in" scenario approach through cap on annual emissions, whereas scenario modelled using top-down modelling is often the output of bottom-up modelling. Top-down methods are also well-suited for analysing the effects of specific measures, such as changes in taxation. The analysis of individual cases may involve simple scenarios or the use of more advanced methods, such as technology deployment models.

In addition to this, cross-impacts and indirect effects can be taken into account in different ways through the use of the various modelling methods. For example, when analysing an individual case, all the values affecting the results are static input values, whereas in partial equilibrium (and computable general equilibrium) models, they can be endogenous variables, in which case some cross-impacts will be taken "automatically" into account within the model.

Analysis of cost-effectiveness in various sectors

Pöyry's report focuses on the following sectors: transport, building-specific heating and agriculture. The key observations concerning the various sectors that were made based on the literature review are presented below.

Due to the large number of inaccuracies and uncertainties, it is very difficult to compare the cost-effective measures of different sectors. The comparison is not unambiguous because different sectors typically prepare calculations from different perspectives and emphasise different factors.

Transport

In terms of emissions, the transport sector is the largest of the effort-sharing sectors and has the greatest potential for emission reduction. There is a considerable number of cross-impacts and indirect effects in the transport sector, due to which analysing the emission reduction measures of the transport sector is challenging. Furthermore, the transport sector has considerable indirect and more general effects on the national economy due to the nature and size of the sector. Measures may have effects on the employment in various sectors and on the purchasing power of consumers. Indirect effects alone may have a 20-30% effect on the total costs.

A common method in the transport sector is a sector-specific analysis of the transport sector, with general equilibrium models used to supplement the analysis. The transport sector itself is typically modelled using a partial equilibrium model, in which the technology selection is modelled at the level of either consumers or systems, with costs minimised in relation to the CO_2 emission limit specified for the scenario.

The typical baseline is the expected development of the transport sector excluding any future measures, which are created using a separate model. An exception to this is, for example, a report prepared by PwC for the German government. The report includes no actual baseline, but emission reductions and costs are analysed based on the assumption that there will be a specified number of electric cars on the market (80,000 cars/year), which will replace petrol-driven and diesel cars to a specific extent. In other words, the generalisation rate of electric cars is an exogenous (model-external) variable in this example. As a rule, scenarios compared against a baseline are mainly normative (predictive or target-oriented). This means that a ceiling for the annual CO_2 emissions is specified for the model, with a partial equilibrium model being used to determine the most cost-effective vehicle and technology portfolio with which the objective can be achieved. In this case, the selection of transport technology is an endogenous (model-internal) variable.

The consideration of cross-impacts depends on the case and model. In terms of costs, usually only the direct technology costs are taken into account. Somewhat different methods have been used to analyse cost allocation. Often used approach is to calculate the technology costs, or general equilibrium costs or, in many cases, both. In this case, technology costs mean the costs of alternative technologies compared to the baseline, with the most common comparison being the life cycle costs of an electric car vs. the costs of petrol-driven cars times the number of electric cars taken into use. Costs are typically discounted using a social discount rate. The results are presented either as EUR/tCO_2e for a specific technology, as sector-level total costs or as a percentage of GDP.

Building-specific heating

Building-specific heating is a significant cause of greenhouse gas emissions in several countries, due to which the related cost-effectiveness measures concerning emission reductions has been widely discussed. The most common modelling methods for building-specific heating include the analysis of individual cases, static models and partial equilibrium models. The sector is usually modelled independently instead of as a part of other sectors or the total national economy.

Based on the literature review, it can be stated that the baseline is typically either the expectations concerning the development of the construction sector, as outlined in the country's latest climate strategy, or alternatively, a business-as-usual type of a model, which is based more on history data.

Usually, the baseline is compared with an alternative scenario. The scenario can be based on, for instance, on a situation where additional climate measures have either been or have not been implemented. The scenarios enable the production of data that helps decision-makers review, for example, the cost-effectiveness of various political measures. In the models for the construction sector, a critical path can be calculated. The critical path is something that should be completed by certain milestone years in order for the climate strategy objectives to be at all achievable. In the models for the construction sector, such critical paths are related, for example, to the coverage of the district heating network or the number of air source heat pumps that should be installed by some specific year. In conclusion, the calculations for the construction sector often use normative scenarios and partly predictive and explorative scenarios.

One of the most important variables in the construction sector is buildings or apartments, one of which is often the key calculation unit. In addition, units related to other technologies, such as air source heat pumps and the coverage of the district heating network, are typical variables used in calculations. In terms of costs, the calculations for the construction sector focus mainly on the technology costs. There are both variable and fixed costs related to these.

As in many other sectors, only the total costs are discounted in the construction sector instead of discounting, for example, emissions. The social discount rate (3.5-4%) is typically used as the discount rate. The emissions of the construction sector are typically measured as the reduction of greenhouse gas emissions, with tCO_2e or merely tCO_2 (not equivalent) as the unit.

When analysing the relationships between various sectors, the construction sector is often linked to the energy sector, which is natural due to the overlaps in the industries. For example, if the number of ground source heat pumps increases, so does the load on the electricity network. The number of ground source heat pumps may also have an effect on the price of electricity. Based on the literature review, relatively few cross-impacts with other sectors are considered in calculations when modelling the building-specific heating sector. In studies that include the modelling of cross-impacts, or in which their modelling has been explained, cross sectoral link is often modelled using first-order impact or by using industry specific correction coefficient.

The heating solutions for buildings also have other effects when various perspectives are being considered. One of the most important perspectives is the effect that building-specific heating has in terms of social-economic issues. As housing and, therefore, buildings are some of the key elements impacting our society, the effects that various steering methods have on the different groups in our society must be considered.

Agriculture

In terms of the cost-effectiveness calculations for emission reduction measures, the agricultural sector is a challenging area because the emissions originating from agriculture are reported under three different sectors depending on the measure and greenhouse gas emission in question. These non-energy related agricultural emissions account for approximately one fifth of the emissions in the effort-sharing sector. The land-use sector (LULUCF), which is not part of the effort-sharing sector, reports carbon dioxide emissions related to agricultural land, excluding emissions from liming, which are reported under the agricultural sector. In addition, emissions from agricultural equipment and building-specific heating are reported under the energy sector.

Due to the differences in the emission reduction measures for agriculture, developing one uniform baseline is also challenging. For example, at the current level, the cultivation of organic land can mean either the clearance of forest for grassland farming, which still takes place on cattle farms, or it can mean traditional grain growing with a gradual transfer to direct drilling. Therefore, separate baselines should be developed for the emission reduction measures. Regardless of the emission reduction measure, comparing the reduction of greenhouse gas emissions to a situation in which the reduction measure in question is not implemented is the most natural comparison.

However, so-called no-regrets methods are also applied to the agricultural sector. These methods include, for example, more accurate fertilisation through technology, lighter tilling and using less productive agricultural land as green fallow instead of growing grain fodder.

The key in cost estimations is that the farm owner or cultivator is the party that the measure concerns, which means that the perspective when calculating the cost-effectiveness of the agricultural sector differs from that in other sectors. Several emission reduction measures require changes to, for example, land use, cultivation operations and even production, which have a direct effect on the livelihoods of individual farms and that is why they may also have direct cost effects.

In the agricultural sector, the cost-effectiveness of emission reduction measures is often presented with marginal cost curves, that is, MAC curves. MAC curves usually present the emission reduction potential for the various areas in agriculture in relation to their costs in some specific geographical region. For this reason, the results presented using a MAC curve are linked to both a region and a sector and do not provide information, for example, on the marginal cost of sector-external emission reductions.

Conclusions and recommendations

In conclusion, the transparency of cost-effectiveness calculations is often insufficient. For example, calculation assumptions are often described insufficiently, which makes it more difficult to compare different analysis results and build on or develop the analysis further. Therefore, the cost-effectiveness analysis and calculations for emission reductions should be more open than they currently are in terms of both the applied calculation methods and background assumptions. This would enable better comparison of the measures in the reports provided by various parties. At the same time, it would result in better understanding of the results of individual reports and of the effects that various factors may have on cost-effectiveness estimates. Furthermore, increased openness would also enable wider discussion and the development of methods of analysis based on previous reports.

In Finland, the cost-effectiveness evaluation of emission reduction measures has not yet been systematically evaluated by using the same evaluation objects and modelling methods. For this reason, Finland should systematise the planning of the emission reduction measures and steering methods that are required to achieve the emission reduction objectives. In addition, the benefits achieved through the measures and the cost-effectiveness of the measures should be monitored systematically. With continuous monitoring, the required corrective actions can be implemented in a timely manner, and the climate objectives can be achieved in the long term as cost-effectively as possible. A systematic approach would also increase the comparability of various reports and reduce uncertainty.

Best practices could be adopted more comprehensively from other countries. In the most important reports from Germany, calculation assumptions are explained well; Great Britain has a centralised body having a diverse role in cost-effectiveness calculations and their development; and Sweden often carries out ex-post follow-up on the accuracy of calculations.

The examination of cost-effectiveness also requires that the discussed concepts are clarified because ambiguous concepts can lead to misunderstandings or confusion when utilising various methods and the reported results. On the other hand, there is always a lot of uncertainty concerning the estimates of costs and emission reductions. Consistency is required when measuring cost-effectiveness, for example to decide which costs are included, how the costs incurred by various parties are taken into account and how the avoidance of emissions is calculated.

Having more systematic cost-effectiveness evaluation for emission reductions requires better cooperation between ministries and the parties preparing the cost-effectiveness calculations. The analyses are complex and multi-disciplinary and should be viewed from several perspectives, which can be achieved through the development of cooperation. In addition, cooperation and the sharing of responsibility between ministries are important for the development of operations in order to ensure that the reports aiming at the evaluation and selection of the most cost-effective emission reduction measures are prepared systematically and the work is steered.

Further reading

Project report: Evaluation of the cost-effectiveness of emission reduction measures: http://urn.fi/URN:ISBN:978-952-287-802-1

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