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English summary

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Summary

Investment projects are subject to uncertainty. Many uncertainties are unsystematic, i.e., they are specific to each project, and can be ignored in Cost-Benefit Analyses because they disappear in the large portfolio of current and former investment projects that constitute the national wealth. By contrast, other uncertainties are systematic and therefore affect the total return on society's investments. Systematic uncertainties in a project should be taken into account in Cost-Benefit Analyses, and it is the project's contribution to total uncertainty in the national wealth that is of interest.

In Cost-Benefit Analyses of investments projects, systematic uncertainty can be taken into account either "through the discount rate" or "through calculation prices" (use of certainty equivalents (CEs). Using the discount rate means in practice to determine one parameter only, namely the risk premium of the discount rate (even if, in principle, there could be several discount rates). It provides a relatively simple yet stiff and inflexible way to model uncertainties. Using calculation prices means to determine many parameters, namely the CEs associated with each cost and benefit element. This is more work, but in return, the uncertainty in each component can be modeled individually.

The first studies of discount rates in Norway recommended a rate that reflected the private sector's return on capital, and that was also considered consistent with consumers' saving behavior (Johansen, 1967; NOU 1983:25). The recommendation was an annual real discount rate of 10 percent, which later became 7 percent. The discount rate was supposed to include compensation for risk, and in practice meant accounting for uncertainty "through the discount rate." However, to the extent that uncertainty was assessed, it was assumed that all projects had the same risk level.

Over time, there was a growing concern that a common discount rate for all investments was too inaccurate, because some public projects contributed more to the systematic uncertainty than others. For a period, another solution was tested; projects were placed into categories according to risk level, and for each category there was a matching risk-adjusted discount rate (NOU 1997:27; NOU 1998:16).

A recent review from a committee appointed by Royal Decree (NOU 2012:16) recommends the use of a standardized real risk adjusted discount rate: "*for use in Cost-Benefit Analysis of a normal public intervention, as for example a transport infrastructure project, a real risk adjusted discount rate of 4 percent is reasonable for the effects in the first 40 years from the time of the analysis.*"

Are the different components in a Cost-Benefit Analysis uncertain to the same degree?

History shows that the discussion goes back and forth between the discount rate and certainty equivalents (or rather, between "a simple rule" that is appropriate for an average project versus separate modeling of the systematic risk of each investment). The discount rate implies fewer parameters to be determined, but also less flexibility. CEs provide flexibility, but more parameters must be determined. In such situations, a useful contribution is to study how systematic uncertainty actually affects the Norwegian economy. If the main benefit and cost components are uncertain to differing degrees, the use of CEs is favored. By contrast, if uncertainty is relatively similar between components, the discount rate is favored.

Apart from the early work of Halleraker (1995), to our knowledge, our study is the first attempt to examine this issue in Norway. We set up an economic equilibrium model for a small open economy with two sectors: sheltered and competitive. The Norwegian economy is exposed to normally distributed and independent productivity shocks in both sectors and shocks to the Government Pension Fund. As a result of the shocks, distributions of national income, wages, capital income, and willingness to pay for non-market goods ("time") occur. On this basis, we derive the correlation between wages, capital income, and willingness to pay on the one hand, and national income on the other hand. National income is interpreted here as the return to the national wealth, and the other variables are interpreted as the return on sub-assets of the national wealth. The correlation between these variables gives a basis for assessing whether the key benefit and cost components are uncertain to differing degrees or to about the same extent.

If the components are uncertain to the same degree, use the discount rate.

Our figures indicate clearly that the major benefit and cost components are uncertain to about the same extent (Table A).

Table A. Effective rate of return for important cost and benefit items

Component	Rate of return
Labor	4.2
Total capital	4.3
Non-market good	4.0

Note: A normal discount rate of 4 percent is assumed.

Given a normal discount rate (return of national wealth) equal to 4 percent, as proposed in NOU 2012:16, we arrive at an effective discount rate for the most important cost and benefit components. The effective discount rate summarizes the effect of a normal discount rate and certainty equivalents. Table A shows that the rates are very close to the normal rate of 4 percent.

Given the stylized nature of our model, one should not place too much emphasis on the differences that occur between components. Our recommendation is to use discount rates to correct for systematic uncertainty in most projects. Currently, the proposed risk-adjusted discount rate is 4 percent. Alternatively, CEs can be used, but for practical purposes they should be equal and adjusted so that the effective discount rate is 4 percent.

We do not take a position on whether 4 percent is an appropriate level for the normal, risk-adjusted discount rate. The only effect it has on our results is to give them a nominal anchor. Whatever the normal discount rate is, our figures indicate that the components can be treated equally and that the discount rate can be used.

Short-term versus long-term projects

We have performed a large number of sensitivity analyses, and have found that the model results are generally robust to the size of the shock and the size of substitution elasticities in demand and production. Among others, we have performed a calculation called "long term." By long term, we mean, for example, ten years. The calculations in Table A are thus "short term." The "long-term" calculation is motivated by the fact that the systematic uncertainty may not necessarily increase exponentially in that good and bad periods offset one another. However, we assume that the uncertainty in the long term is 50–100 percent larger than in the short term. We assume also that the economy in the long term is more flexible than in the shorter term, and we assume a substitution elasticity in production of 1.0, instead of 0.5 as we had in the short term. Table B indicates that the results are very robust to the aforementioned changes.

Table B Effective rate of return in the short term and long term

Component	Short term	Long term
Labor	4.2	4.2
Capital	4.3	4.3
Non-market good	4.0	4.0

Note: A normal discount rate of 4 percent is assumed.

The results thus indicate that discount rates should be used to adjust for systematic risk not only in the short term, but also in 10 years time. With increasing time period, our model assumptions correspondingly fit to a lesser extent. On the basis of our results, there is still little to indicate that it is better to switch to using CEs in the long run. A whole other issue is that the normal discount rate itself should probably decline in the long term. We take no position here; see NOU 2012:16 for discussion.

Special projects

Our recommendation is that in most projects an appropriate way to deal with systematic uncertainty is to use a risk-adjusted discount rate. More specifically this applies to:

- Projects where only the cost side is priced. We have examined the major cost components, labor and capital, and the results are shown in Tables A and B: There is little or no difference in the cost components. Most projects have additional costs associated with intermediate goods. This does not affect the recommendation.

- Projects where the benefit is measured as market income.

- Most projects where the benefit is related to time, environment, accidents, safety, and any similar forms of willingness to pay. Our results suggest that uncertainty in willingness to pay is handled well through the discount rate. We have not examined the case where the quantity is also uncertain (not only the price), and thus we have limited the study to projects with relatively low systematic risk. Still, we conclude that the discount rate can be used. In some projects, the quantity can be affected by uncertainty (e.g., a road used more in boom times than in recessions. The volatility will then be somewhat higher. Without having investigated this, we do not know if it makes impact in practice.

There may be projects with a risk profile that is so different that certainty equivalents should still be recommended. In our view, this is particularly the case for the following:

- Projects with cost-benefit flows that are completely certain over time. In such projects, the risk-free part of the normal discount rate should be used for the components that are certain. The rest of the project should be discounted with the normal discount rate and CEs per unit of time equal to one. For example, full certainty may occur due to contracts.

- Projects with benefit flows that are low in a normal economic situation, but high in a recession. In such cases we talk about projects that function as

"insurance" against a bad economic situation for the country. In Norway, such projects can be found within the area of "regional development" (in the event that oil prices go down) and certain projects to reduce the global climate problem. In cases where the project benefits contribute to insurance against a bad economic situation for the country, CEs should be used on these benefit components, equivalent to a discount rate that is lower than the normal discount rate.

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Forskningsprogrammet Concept skal utvikle kunnskap som sikrer bedre ressursutnytting og effekt av store, statlige investeringer. Programmet driver følgeforskning knyttet til de største statlige investeringsprosjektene over en rekke år. En skal trekke erfaringer fra disse som kan bedre utformingen og kvalitetssikringen av nye investeringsprosjekter før de settes i gang.

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The Concept research program aims to develop know-how to help make more efficient use of resources and improve the effect of major public investments. The Program is designed to follow up on the largest public projects over a period of several years, and help improve design and quality assurance of future public projects before they are formally approved.

The program is based at The Norwegian University of Science and Technology (NTNU), Faculty of Engineering Science and Technology. It cooperates with key Norwegian and international professional institutions and universities, and is financed by the Norwegian Ministry of Finance.

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Høgskoleringen 7A
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Trondheim
NORWAY

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