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Abstract

The appraisal of public investments is subject to formal guidelines which often require input prices, such as forecasted energy prices. Using Danish guidelines as a case study, we explore the discounting assumptions in these input prices and find rates ranging from 2.97% to 17.5%, markedly different from the headline discount rate of 3.5%. This is not unique to Denmark and discrepancy in embedded discount rates can lead to false rejection of projects. We offer three possible explanations for such differences, based on positions on how the discount rate should be set.

JEL-Codes: D610, H430, L510, Q480.

Keywords: discounting, social discount rate, cost-benefit analysis, public guidelines.

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Introduction

Public appraisal “is the process of assessing the costs, benefits and risks of alternative ways to meet government objectives” [1]. As part of this process, social cost-benefit analysis (SCBA) is a well-established method for quantifying whether a proposed new regulation or public investment is expected to benefit society more than the costs associated with implementing it [2].

SCBA methods are commonly based on the calculation of expected net present values (NPVs), based on the estimated flow of future societal benefits net of costs expected to result from the proposed regulatory change or public investment. The expected net benefits enter the numerator of the NPV criterion [2]. These are converted to present values through the denominator by applying a real social discount rate (SDR), quantifying how much more societies value monetised net benefits today compared to the future. The estimated NPV can be extremely sensitive to the choice of SDR, particularly for long-lived projects such as those associated with climate change mitigation [3]. For this reason, considerable academic attention has been given in recent years to estimating the SDR [4].

Many government departments and agencies provide detailed guidance to public bodies on incorporating the latest advances in SDR theory and empirics into their SCBA [5]. Yet, despite incorporating many recent relevant scientific advances into policy practices, there is still the genuine risk that discounting may not be applied consistently. This is because of an effect that we call “embedded discounting”, exemplified in Equation 1:

$$NPV = \sum_{t=0}^{T} \frac{B_t(P_{1t}(\rho_{1t}), \ldots P_{nt}(\rho_{nt}), X_t)}{(1+r_t)^t} \quad (1)$$

For each period $t \in [1, T]$, the expected net benefits, B_t, are discounted at the SDR (r_t) for that maturity to derive the social NPV. The net benefits themselves, though, are estimated through calculations that include embedded prices, $P_{1t}, \ldots, P_{nt}$, and a vector of other input variables, X_t. For energy-related public investments, $P_{1t}, \ldots, P_{nt}$, are frequently based on forecasts of fuel prices, the social cost of greenhouse gas emissions and other pollutants. These forecasts have themselves been derived from models that apply discounting with their own embedded discount rates (EDRs), $\rho_{1t}, \ldots, \rho_{nt}$. Our central contribution is to observe that these EDRs used in the numerator are unlikely to be empirically or conceptually consistent either with each other or with the “headline” SDR used in the denominator, r_t. Such differences could be of concern for the project appraisal if they reflect fundamental inconsistencies in the way intertemporal welfare is assessed across different elements of the SCBA.

We illustrate embedded discounting through the Danish guidelines for SCBA of district heating (DH) investment [6]. DH is a network-based energy supply: heat is generated from central sources and distributed to end-users through a network of pipes. Danish regulation requires SCBA for DH investments to secure the societally least-cost heat supply. In this SCBA, the SDR applied is consistent with general governmental guidance [7]. The SCBA guidelines also provide model-based price forecasts of fuels, electricity, and emissions. These are used for estimating the future cost and benefits. Apart from our previous analysis specifically for a single DH project, published in a policy-oriented paper upon which this study builds [8], existing research on discounting and DH has primarily focused on the discount rate’s impact on the overall level of investment, e.g., [9]. By contrast, our focus is the internal consistency in discount rates applied in the SCBA more generally. Differently from the policy-oriented paper [8], the present paper also makes conceptual contributions.

While we focus this letter on the Danish guidelines, there are other international examples where EDRs differ from the headline SDR. Thus, the risk of inconsistency applies to SCBA across many sectors of the economy. For example, European countries rely on CO_2 prices inferred from how carbon emissions are regulated within their public appraisals. How emission costs, fuel and electricity prices are modelled and evolve incorporate very different discounting assumptions than the headline SDR. This pervasive presence of embeddedness merits greater attention from economists, and embedded discounting assumptions should be more explicitly highlighted to regulatory decision makers, who may take price forecasts as given.

Case study: Danish guidelines

We explore the EDR in the price forecasts prescribed in the Danish Energy Agency's 2019 guidelines for appraisal of DH projects [6]. The headline real SDR is 3.5%, comprised of a real risk-free component of 2% and a generic risk premium of 1.5%, set by the Danish Ministry of Finance [10].

The forecasts of prices used to calculate costs and benefits come from a wide range of sources [8], which include:

- Fossil fuel price forecasts derived from the IEA's World Energy Outlook (WEO-2020). These are then fed as inputs into the RAMSES model for forecasting electricity prices.
- Forecasts of woodchip prices, both for incorporation in the RAMSES model and independent use in the analysis, are derived from the Global Change Assessment Model (GCAM).
- The social cost of carbon is projected forward from the prevailing EU ETS price under the standard Danish Ministry of Finance procedure. For non-EU ETS emissions, costs are based on the PRIMES model, assuming that EU greenhouse gas emissions will be 40% lower in 2030 compared to 1990.
- The social costs of other pollutants (SO_x, NO_x and $PM_{2.5}$) are derived through the Economic Valuation of Air Pollution Model System (EVA).

We observe that apart from EVA, each of these forecasts use independent discount rates or expected rates of return, i.e. EDRs, that differ from the headline SDR [8] (see also Figure 1):

- WEO-2020 considers private economic interactions rather than being based on social factors. For OECD countries, with some variations, the model is based on an assumed weighted average cost of capital (WACC) of 8%.
- Future EU ETS prices are estimated using the current market price projected forward based on the German 10-year Treasury yield plus a risk premium of 3.5%. Given the negative real yields that prevailed in Treasury markets at the time, this corresponded to 2.97%.
- For non-EU ETS prices, PRIMES is based on assumptions about several different sectoral WACCs ranging from 8% to 17.5%.

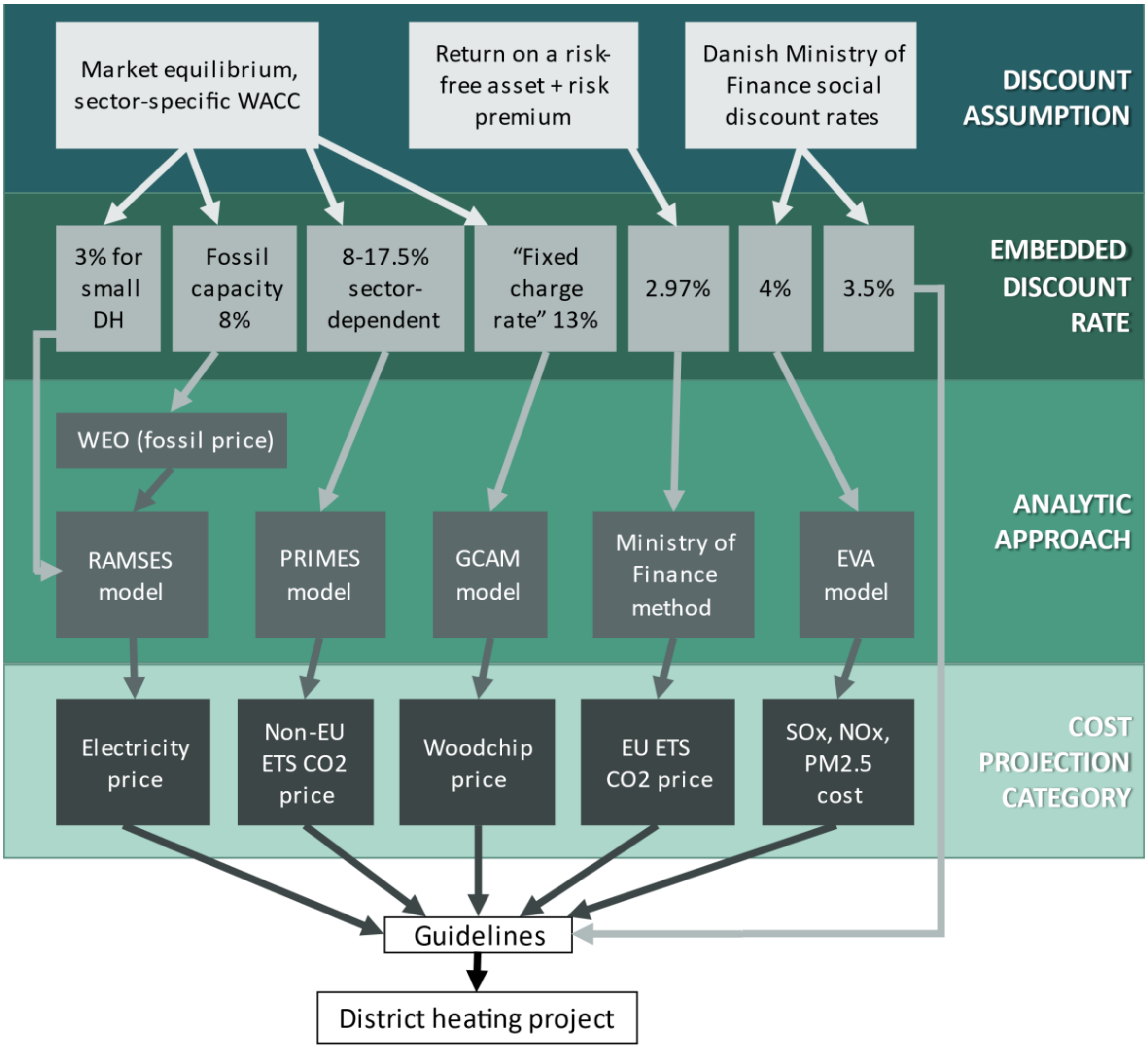

Figure 1: Embedded discount rates for pricing forecasts in the socio-economic analysis of a district heating project. The GCAM and RAMSES models do not appear to be explicit about whether their rates are real or nominal. From reading their guidance, though, both lead us to infer that they are real. All other rates are real.

- GCAM is slightly less transparent but appears to apply a fixed charge rate of 13% for technology costs. This rate includes "depreciation, interest rate, taxes and return on equity".
- EVA is most consistent with the headline SDR. However, at the time of reviewing the guidelines (2020) it used the previously recommended SDR of 4% rather than the updated 3.5% rate that had recently entered into force.

While the chosen rate is carefully justified within the documentation of each of the models described above, the wide range of different EDRs (2.97% to 17.5%) is stark. We contend that there are three possible broad strands of explanation for this variation.

First, many different approaches for determining the discount rate have academic and policy support (e.g. [11]). These take conceptually conflicting positions on how the discount rate should be set, particularly on the extent to which financial market yields are relevant and whether we should treat the welfare of future generations as equally important to our own. The observed rate differences may be caused by an analyst familiar with the headline SDR framework of the Danish Ministry of Finance, deciding that one conceptual approach is appropriate in one setting while another should be applied elsewhere. For example, while price forecasts for fuel and CO_2 reflect future private-economic market prices, the price forecasts for other pollutants are estimates of their future social cost. This explains why the EVA-model applies the previously recommended SDR, while the other models apply a market-based discounting framework.

Second, different costs and benefits may be discounted at different rates within any conceptual discounting framework. Most commonly, this is caused by differences in risk across projects and regulations, as captured by the "beta" of many asset pricing models. However, the project's maturity may also influence the discount rate, with longer-term projects often being assigned a lower discount rate (e.g. [1,12]).

The third possibility is that, in isolation, each analyst is independently choosing the discounting framework they believe is most appropriate to their model without considering whether other analysts are making conceptually similar choices. As we have been unable to find evidence in the documentation of each model that refers to systematic cross-referencing on these matters, we believe this is likely to explain at least part of the differences in the discount rates applied across the SCBA guidelines.

Our central observation is that while the Danish Ministry of Finance and many other governmental bodies give considerable effort to setting their headline SDR, we are aware of no previous work that has considered the extent to which EDRs, such as those used by the Danish Energy Agency, should be made either numerically or conceptually consistent with the headline rate. In addition, in informal conversations with those involved with other Danish DH appraisals, embedded discounting's influence on the final NPV has gone largely unrecognised. Given this, we believe that ensuring consistency in rates used across all aspects of SCBA analysis is essential.

Conclusion

Our analysis of the SCBA guidelines in Denmark highlights the diverse assumptions on discounting that is embedded in the numerator of the NPV criterion. Many EDRs differ markedly from the real 3.5% general governmental SDR and by as much as 14% in one case. This potential inconsistency in discounting assumptions, not unique to Denmark, can falsely reject projects. Even if the EDRs for price forecasts are set consistently across all private economic models, reflecting the prevailing conditions on the capital market, there is no guarantee that such prices are consistent with social preferences. As a starting point, the regulator should investigate these disparities. Ensuring rate consistency throughout SCBA analysis is a crucial area for future research.

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