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A critical view on benefit-cost analyses of silvicultural management options with declining discount rates

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ABSTRACT

The long planning perspective is one of the unique features of forestry. How to value money flows expected in the far distant future is therefore a crucial question. Applying time declining discount rates (DDR) may offer an appropriate alternative to conventional discounting, but few studies have applied DDRs in forest economics. We expect that theoretical assumptions behind welfare analyses based on DDR will be important. Using a dataset from the UK (Davies and Kerr (2015) [Forests 6: 2424–2449]) we investigate the effects of 1) more than marginal contributions from forestry to consumption, 2) the role of the assumed scenarios for return on capital, and 3) ignoring optimization (i.e. adopting predefined management scenarios) on the ranking of different silvicultural strategies. These include various clearfelling options (with replanting, natural regeneration or underplanting) and the transition to continuous cover forestry. Our analysis reveals that changes in these aspects affect the ranking of forest management options more strongly than a pure change in the coefficients of a benefit cost analysis. Decreasing marginality, cautious assumptions about the worst-case return on capital and optimization of silvicultural operations all increase the relative attractiveness of continuous cover forestry. We conclude that applying DDR makes valuation in forestry more demanding and should be applied with appropriate care. In addition, the precise assumptions behind the particular schedule of DDRs should be explicit. Finally, theoretical considerations support the importance of combining optimization of silvicultural management strategies with their economic evaluation.

1. Introduction

Planted forests contributed 46% of the world's industrial roundwood in 2012 (Payn et al., 2015). Plantations are usually monocultures, managed in short rotations, whereby a cycle concludes with clearfelling all timber (Cubbage et al., 2007). Alternative silvicultural management methods, such as closer-to-nature approaches using mixed tree species and maintaining a continuous cover of older trees, are less often applied (Puettmann et al., 2015). Economic considerations are a major factor limiting the uptake of alternative silvicultural methods, because the transition phase to continuous cover forestry may lead to losses compared to the clearfell system. The economic attractiveness of management options hinges heavily on the evaluation of such intertemporal choices. Discounting is the usual method to support intertemporal decision-making in international forest economics and forest management optimization (Amacher et al., 2009).

However, using discounting to evaluate the future benefits and costs of forest management often leads to recommendations that are different from the forest management schemes developed in practice (Möhring, 2001). Usual recommendations resulting from discounting include shortening rotations, reducing forest densities, and introducing monocultures comprised of fast growing, often exotic tree species. These recommendations, however, strongly depend on the discount rate. For example, Brukas et al. (2001) showed for Baltic forestry that setting a discount rate of $r = 0.03$ would lead to much shorter rotation periods and significant shifts in tree species composition. Concerned about these results, they suggested discount rates of around $r = 0$–0.02 for public forestry. Moreover, aiming for the highest (theoretical) level of economic efficiency often results in discontinuous management and timber flows (Tahvonen and Kallio, 2006; Hahn et al., 2014). Discounting with higher discount rates therefore often challenges the sustainable yield paradigm. These consequences of using a mathematical economic calculus to inform forest management led very early to controversial and often quite emotional discussions among foresters (Fernow, 1911). In these discussions, some forest scientists have suggested "maximum sustained yield" as the only valid criterion to optimize forest management, based on a discount rate tending to zero. In contrast, other authors have advocated the maximization of the land

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rent through discounting with a rate greater than zero. For example, Samuelson (1976) questioned the argument that for a forest property in a steady state (i.e. a fully-regulated forest), no interest rate needs to be considered in management decisions. The world's plantation forestry still follows the maximization of the net present value using constant, at times quite high, discount rates (Cubbage et al., 2007). Consequently, the apparent long-lasting conflict between sustainable forest ecosystem management and the conventional economic approach to maximize the present value of future benefits and costs, continues (e.g. Toman and Ashton, 1996). In this context Hepburn and Koundouri (2007) confirm a considerable interest in the conceptual basis for discounting and the selection of the discount rate in forest economics, but not many studies have been carried out since then (with a few exceptions, such as the study by Price, 2011).

Consensus is now growing in the economics literature about time-declining discount rates (DDRs) as an option for a more appropriate evaluation of the far distant future (e.g. Freeman et al., 2015). This approach places higher value to benefits and costs in the far distant future than conventional discounting and is possibly a means to more appropriately acknowledge the benefits and costs of alternative silvicultural systems that are associated with long-lasting consequences.

Forestry provides an ideal example for applying DDRs, because the consequences of forest decision-making reach very far into the future. However, forest economics studies associated with DDRs are still rare. One example is Hepburn and Koundouri (2007), who discuss using DDRs to evaluate forest projects in general. Another example is Price (2011), who investigated the optimal rotation with DDRs.

Davies and Kerr (2015) applied DDRs to calculate net present values for clearfelling based and continuous cover forestry in Sitka spruce (*Picea sitchensis* (Bong.) Carrière). Their schedule for DDRs follows a suggestion in the HM Green Book (2003), which is a UK guide for the appraisal and evaluation of Central Government projects. The main aim of this guide is to ensure "… that public funds are spent on activities that provide the greatest benefits to society, and that they are spent in the most efficient way …" (HM Green Book, 2003, p. V).

The study by Davies and Kerr (2015) is valuable because Great Britain is a good example for Central European plantation forestry with fast growing, exotic tree species. Concerns about this type of forest management and discussions about alternative silvicultural methods already started some decades ago (Cameron et al., 2001) and are ongoing. Davies and Kerr (2015) compare DDRs with conventional discounting, but their results do not reveal any substantial differences in the ranking of alternative silvicultural management options when applying DDRs. Two clearfelling options, one with and one without natural regeneration, clearly outperform the alternatives, although the continuous cover option shows favorable economic results after an 83 years period. Continuous cover forestry consistently obtained the worst ranking, which is likely to be an effect of discounting, even though the ranking remained quite robust when applying alternative discount rates (Davies and Kerr, 2015). Given the applied evaluation guide (HM Green Book, 2003) focusing on government projects across all sectors of the economy, it is important to review the assumptions that may strongly influence the results of the evaluation, for example when carried out in other contexts. A general problem of carrying out benefit-cost analyses (BCA) about silvicultural management scenarios is also the definition of such scenarios. It is of great interest how the evaluation of pre-defined treatments may influence the results of the BCA of silvicultural options.

The objective of our paper is to increase the awareness of the theoretical foundation of declining discount rates and of the distinction between non-marginal and marginal values in the forest economics' community. This is achieved by analyzing the impact of important implicit assumptions behind the analyses by Davies and Kerr (2015). The tested assumptions will explicitly relate to (A) the marginality of the evaluated projects, (B) the schedule of the discount rates applied, and (C) the definition of the silvicultural management concepts.

In the following section (chapter 2) we will briefly review papers dealing with DDRs. Based on experiences from other scientific fields, we will then outline the key assumptions of DDR analysis carried out by Davies and Kerr (2015) in chapter 3. In chapter 4 we analyze important theoretical aspects of BCA for public projects, present a methodology, adopted from Gollier (2010), for consistently deriving various schedules for DDRs, and describe the silvicultural scenarios investigated. We also introduce theoretical considerations regarding optimizing the timing of silvicultural operations in chapter 4. In chapter 5 we present the results for four silvicultural alternatives and analyze the possible impact of the optimization of silvicultural operations, before concluding with some remarks about the importance of cautious consideration of assumptions behind BCA with DDRs.

2. Support of declining discount rates

DDRs mean that the rate of fall of the discount factor (i.e. the discount rate) declines over time, in contrast to conventional discounting, where the discount rate is constant. Many economic studies have raised concerns about the use of conventional discounting of future benefits and costs for valuing long-term investments. These concerns focus, among other issues, on intergenerational equity (e.g. Toman and Ashton, 1996). Consequently, applying DDRs has become particularly popular in the context of sustainability, climate change, nuclear waste and species extinction. The following section shall provide an overview on existing studies supporting DDRs that are relevant for questions regarding forest economics from various perspectives. We will thus include studies, discussing different approaches towards DDR that are not limited to the one method applied in the remainder of our study.

Following Price (2011), some studies in support of DDRs draw on observations of how people actually discount, while others give weight to the future from various perspectives, or derive conclusions from statistical analyses of real market returns. Some further studies also average assumed scenarios for either market return or consumption growth to analyze the impact on advisable discount rates. For example, Henderson and Bateman (1995) apply hyperbolic discounting to consider how people do actually discount the future. Newell and Pizer (2003) use US American market data to support DDRs. Li and Löfgren (2000) build on Chichilnisky (1997) and aggregate the perspectives of the present, represented by a utility stream discounted with a positive constant rate and of future generations, modeled as a utility stream discounted with a rate of zero. They show DDRs converging to zero in the very long run. Weitzman (1998) and Gollier et al. (2008) demonstrate how an appropriate averaging of scenarios (either for market return or for consumption growth) may lead to declining discount rates. Key messages include that it is not appropriate to average discount rates. Instead, discount factors need to be averaged, which would result in DDRs, at least if discount rates are positively correlated from year to year, i.e. being persistent. For an example of the critique on the usual practice of exponential discounting we may refer to Weitzman (1998, p. 202), who stated: "Few are the economists who have not sensed in their heart of hearts that something is amiss about treating a distant future event as just another term to be discounted away at the same constant exponential rate gotten from extrapolating past rates of return to capital."

One may separate the available approaches to DDR roughly into two groups: Support for DDRs may result from positive (descriptive) and from normative (prescriptive) approaches to analyzing intertemporal decision-making. People's behavior is often time inconsistent from a conventional discounting perspective, with individuals valuing time delays in the near future in a significantly different manner than time delays in the distant future. Following this observation, some authors draw striking analogies between human time preference and animal behavior (e.g. Henderson and Bateman, 1995; Hayden, 2016). Results of behavioral research are often more consistent with hyperbolic discounting, where the observed rate of fall of the discount factor is not