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Research paper

Assessment of uncertain returns from investment in short rotation coppice using risk adjusted discount rates

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ABSTRACT

The increasing demand for renewable energy resources increases interest in the use of short rotation coppice (SRC) as alternative land use activity. The high uncertainty attached to returns from SRC is one of the key adoption barriers to farmers. One possibility to account for the role in investment assessments is the use of project specific risk adjusted discount rates (RADR). In this article, we revisit the theoretical background of RADR and illustrate different assumptions using an example of poplar based SRC. Time-invariant RADR used in the current literature on SRC assessment are found to over-emphasize the role of risk for project assessment and usually give to little weights to returns in future periods, which are of particular relevance for long-term investments in SRC. Thus, the use of time invariant RADR is found to lead to biased recommendations towards the attractiveness of SRC and optimal policy support.

1. Introduction

The increasing demand for renewable energy resources has triggered a significant interest to promote biomass production. Among other drivers, this increasing demand is caused by policy measures such as the target of the European Union that 20% of the total energy consumption come from renewable energy by 2020 [1]. Short rotation coppices (SRC) have been identified as an attractive option for production of biomass for bioenergy and material uses. SRC are characterized by high biomass yields in combination with highly extensive, low-input management. Due to little requirements for external nutrient supply and pesticide application and its positive effects on biodiversity, SRC is often perceived as more sustainable than other bioenergy crops such as rapeseed and maize [2,3]. Trees planted on agricultural land are usually harvested every two to five years. Due to the fact that nutrients are stored in root and stumps, a fast re-growth of shoots is ensured. The total lifetime for use of SRC is on average about twenty years, with values for the lifetime assumed in the literature ranging from eight to fifty years [2]. Tree species that are usually used in SRC in temperate regions are fast-growing and capable of stump sprouting, such as poplar (Populus spp.), willow (Salix spp.) and black locusts (Robinia spp.) [4]. Using SRC for renewable energy production represents a sector with enormous potential in terms of income for growers, the environment and the society at large [5,6].

However, the economic viability of SRC must be given that a relevant adoption can take place. To improve the economic attractiveness of SRC for farmers, various policy measures are in place. For instance, subsidization programs for have been established in Sweden and the UK [7,8]. Moreover, in the Greening component of the European Common Agricultural Policy (CAP), SRC can be accounted for as ecological focus area. Since 2015, 30% of the direct payments paid to farms to the requirement that, among other obligations, farms use at least 5% of their arable land as ecological focus area. These comprise, for instance, field margins, hedges, fallow land. SRC can be accounted here with a factor of 0.3. In contrast, other perennial bioenergy crops (e.g. non-tree species) such as Miscanthus have not been considered here. Thus, SRC has a comparative advantage and will potentially gain further significance. Note that in the past, the CAP allowed to count area under SRC as fallow land (see e.g. Refs. [9,10]).

Despite these support measures, the current uptake of SRC is still limited (e.g. about 5000 ha in Germany, 14000 ha in Sweden, 6000 ha in Italy, 7500 ha in the UK, [11]). The assessment of the economic viability is thus of highest importance to understand adoption barriers and designing appropriate policy measures (e.g. Ref. [12]). High opportunity costs and limited resource availability (e.g. concerning land) are important barriers for adoption. Moreover, the high uncertainty attached to returns from SRC is a key adoption barrier e.g.

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Refs. [2,9], which is particularly caused by the fact that revenues in distant future periods depend on (highly volatile) energy prices.

Hauk et al. [2] recently reviewed the literature on economic evaluation of short rotation coppice systems for energy biomass. It is largely acknowledged that cash flows from an investment in SRC are subject to a very high uncertainty, in particular due to high (energy) price volatility. Despite this fact, Hauk et al. [2] found only 3 out of 37 reviewed studies to consider risk if assessing the economic viability of an investment in SRC. Several approaches can be used to account for risks in investment projects (see Ref. [2] for an overview). For instance, Risk Analysis uses Monte Carlo simulations to derive a distribution of the target parameter (such as the NPV), based on which criteria such as stochastic dominance or stochastic efficiency with respect to a function can be applied to consider risk preferences. Moreover, Real Option Approaches can be used to account for the potential value of waiting (e.g. to invest in a SRC) due to uncertainty about future states. Here, considerations of risk aversion are not necessarily needed. Finally, expected utility approaches allow considering risk preferences of the decision maker. Here, also the uncertainty associated with a cash flow in a particular period and the risk preferences of the decision maker can be directly considered using risk adjusted discount rates (RADR).

Based on their review, Hauk et al. [2] recommend the use of adjusted discount rates to account for the uncertainty with respect to future costs and revenues from SRC. The use of RADR is recommended because it allows to directly consider both the level of uncertainty associated with the future cash flows from SRC as well as risk preferences of the decision maker if discounting future levels of expected cash flows (e.g. Refs. [13–15]). RADR allow considering project specific risks faced by farmers if making long-term investment decisions such as in short rotation coppice. Furthermore, risk adjusted discount rates are the primary way to consider risk aversion in real option analysis, which are frequently employed in recent economic assessments of perennial energy crops (see e.g. Refs. [9,16–19]). The use of RADR is also relevant for risk analysis in practice – for example, Bennouna et al. [20] report that about 77% of surveyed Canadian firms employ RADR.

Despite this relevance, the use of RADR in SRC studies remains limited. Moreover, various studies make the simplifying assumptions of time-invariant RADR. That means, the same level of risk loadings is used to discount cash flows at any level of time (e.g. Refs. [9,18,19,21]). This assumption is motivated by the requirements for use of RADR in real option analysis applications in these papers. We argue that this is, however, only a theoretically valid assumption in a few rare cases. The potential consequences of this assumption with respect to policy conclusions have, however, not been discussed in the literature. Moreover, the specific choice of the RADR used is often based on standard sensitivity analysis, using simplifying assumptions and is thus not well motivated based on economic theory. Our hypothesis is that these assumptions made in the literature cause a misinterpretation of the role of risk for the profitability of SRC. Given the increasing focus on economic assessments of SRC (and other investment in risky perennial bioenergy crops), the correct incorporation and use of RADR is thus a central element for future research.

Based on this background, this paper aims to contribute to fill gaps in the literature as follows. First, we derive the theoretical background of RADR with a particular emphasis on the validity of time invariant RADR. Second, we aim to reveal policy implications of different assumptions on RADR usually made in SRC applications. To this end, a case study on an investment in SRC using poplar trees. Accordingly, the remainder of this paper is structured as follows. In the next section, we derive the theoretical basis for RADR and underline these will numerical examples. Subsequently, we introduce details on the case study and apply RADR in an SRC investment assessment. Finally, we discuss the obtained results and draw conclusions.

2. The risk adjusted discount rate

An uncertain level of cash flow, resulting from today's investment in SRC, occurring in period t is denoted $\tilde{X}_t$. An investor needs to be compensated in two ways to undertake the investment in SRC if future cash flows are uncertain: First, compensation with respect to the time value of money is required, i.e. using a risk free interest rate (reflecting secure foregone investment opportunities). Second, the project risk requires an additional compensation if the decision maker is risk averse.

Thus, the preferences of a decision maker for an uncertain future cash flow can be decomposed in a risk free interest rate i and a risk loading v (note that other papers also use the term risk premium here). The resulting RADR is defined as $RADR = i+v$. Deriving the present value PV_0 for an uncertain cash flow in period t with expected value $E(\tilde{X}_t)$ is thus:

$$PV_0 = \frac{E\left(\tilde{X}_t\right)}{(1+i+v)^t} \tag{1}$$

The choice of v reflects both the riskiness of the project and the risk preferences of the decision maker. Both higher risk and higher risk aversion should result in higher v. In contrast $v = 0$ for risk neutral decision maker, so that standard (risk-free) discounting can be applied.

In the several of applications, the capital asset pricing model (CAPM) is the basis for determining the risk-adjusted rate (e.g. Ref. [15]). For considerations of risk aspects in SRC assessments this, however, has not been used in the literature (cp. e.g. Ref. [9]) because the consideration of individual risk preferences, risk perception and project specific changes of risks over time cannot be considered sufficiently (e.g. Refs. [22,23], for similar arguments in timber applications). In contrast, an approach that focuses on the individual grower explicitly is chosen. To this end, the present value of an uncertain cash flow in period t can be alternatively derived as follows:

$$PV_0 = \frac{CE_t}{(1+i)^t}, \tag{2}$$

where CE_t is the certainty equivalent of the uncertain cash flow in t. CE_t represents a sure amount of cash flow in period t that is rated by the decision maker equivalently to the uncertain cash flows $\tilde{X}_t$. Because the numerator is now representing a riskless cash flow (CE_t), no risk adjustment takes place in denominator, i.e. discounting is based on i only. However, this assumption might be relaxed if there is some general risk to be considered in addition to the project specific risk reflected inCE_t (see e.g. Ref. [24], for further details). We, however, will focus on the case where the entire risk is project specific and any additional (macro) risk is already reflected in the discount rate i. Risk averse decision makers are expected to be willing to give up parts of the expected level of cash flows to remove uncertainty, so that $CE_t < E(\tilde{X}_t)$. The difference $E(\tilde{X}_t) - CE_t = RP_t$ is the risk premium RP_t, indicating the implicit costs of risk, i.e. expresses the 'burden' of facing uncertainty in monetary terms. RP_t thus also reflects the maximum willingness to pay to remove uncertainty from the cash flows in period t. Equation (2) may thus be rewritten as follows:

$$PV_0 = \frac{E\left(\tilde{X}_t\right) - RP_t}{(1+i)^t}, \tag{3}$$