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Are short rotation coppices an economically interesting form of land use? A real options analysis

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ABSTRACT

Short rotation coppice (SRC) is intensively discussed as being an economical and ecological advantageous alternative to traditional agricultural land use. In various countries, farmers have been encouraged through incentives to cultivate SRC. Nevertheless, they often do not switch from conventional land use to SRC, even if SRC is relatively beneficial according to the net present value (NPV) rule. Therefore, farmers do not follow the classical investment theory. A relatively new theory is the real options approach (ROA). The ROA takes further aspects like irreversibility of the investment costs, flexibility regarding investment timing, and uncertainty of the investment returns into account, which the NPV rule ignores. In the case of SRC, investment (conversion) triggers when a farmer should switch to SRC following the ROA can be higher than those following the NPV rule. As it is often the case in real options applications, decision makers' possibility to disinvest in general and farmers' possibility to reconvert, in particular within the useful lifetime of SRC, is not considered. We build a model to calculate the conversion triggers for switching from annual crop production to SRC following the ROA. We consider the opportunity to reconvert the land and evaluate the respective effects on the conversion triggers according to the ROA. Furthermore, we analyze the effect of a former governmental incentive, in terms of an investment subsidy, on the conversion triggers of both theories. Our calculations show that following the ROA, a farmer should change land use to SRC more slowly than when following the NPV rule. Furthermore, neglecting the reconversion possibility would cause considerable bias amongst the results. The consideration of investment subsidies diminishes the conversion triggers of both theories. We conclude that the ROA can at least partially explain farmers' inertia of converting to SRC.

Introduction

Short rotation coppice (SRC) is more commonly known as the process of planting trees on agricultural land which can be harvested frequently within a few years' time. Currently, the process is being deeply discussed as an alternative form of land use in European countries such as Sweden, Germany and the UK (Mitchell et al., 1999; Larsson and Lindegaard, 2003; SAC, 2008). SRC has also gained interest in Canada and New Zealand (Sims et al., 2001; Rockwood et al., 2004).

Several studies have shown that SRC is ecologically advantageous compared to intensive agricultural land use (Hall and House, 1995; Bryan et al., 2010; Lasch et al., 2010; Langeveld et al., 2012). Moreover, SRC can be more profitable than annual crops (Heaton et al., 1999; Schoenhart, 2008; Wagner et al., 2009). Especially in areas with marginal soil qualities and high levels of groundwater, SRC is from a single farms' point of view competitive because it obtains high and stable yields, despite poor soil quality (Murach et al., 2009; Stolarski et al., 2011).

To support farmers' willingness to convert to SRC, incentives have been established. In Germany, farmers in the federal state of Mecklenburg-Western Pomerania have been allowed to plant SRC on permanent grassland (DGErhVO M-V, 2008) which is not allowed in other federal states of Germany. Farmers in the UK were encouraged to plant SRC with a general planting grant of 400 GBP per hectare for set-aside land and 600 GBP per hectare (equal to approximately 700 €/ha) for non-set-aside land (Mitchell et al., 1999; SAC, 2008).

Despite SRC becoming a more profitable alternative to traditional agricultural land use, few farmers are actually converting to SRC. Although Murach et al. (2009) show that for the Northeast of Germany, the potential area for SRC is up to 200,000 ha, there had only been 5000 ha converted to SRC by 2011 in all of Germany (Marron et al., 2012, p. 116).

If SRC can be competitive with annual crops from a single farms' point of view and farmers do not realize converting to SRC, it is

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necessary to identify farmers' underlying reasons. A part of the inertia can be explained, for example, through the relatively high investment costs in combination with missing financial capital and the technical lack of knowledge (Marron et al., 2012, pp. 114–118). Moreover, traditional behavior in terms of long lasting binding of the land and the investment costs (Marron et al., 2012, pp. 114–118) as well as bounded rationality may cause farmers' inertia.

It is necessary to evaluate SRC as an investment because its useful lifetime amounts to more than 20 years, and the plantation is expensive. When applying the classical investment theory, decision makers in general and farmers in particular choose the land use which promises the highest net present value (NPV). However, if farmers convert to SRC, they first have to take into account that the high costs for the establishment of the plantations are sunk. Second, farmers can postpone the conversion to SRC. Third, SRC are related with uncertain returns because the prices for the harvested wood chips are volatile. The classical investment theory ignores irreversibility and flexibility regarding the timing of investment as well as uncertainty of investment returns (Trigeorgis, 1996, p. 1). However, this can be highly important in causing farmers' inertia to invest in (convert to) SRC because it influences farmers' investment behavior. Because of not considering these aspects, the NPV rule could be perhaps not extensive enough to capture and evaluate farmers' decision situation. A relatively new theory, which takes into account these aspects that the NPV rule ignores, is referred to as the real options approach (ROA) (Dixit and Pindyck, 1994, pp. 3–25). The investment (conversion) triggers which induce the cultivation of SRC calculated by the ROA could be shifted upwards, compared to the conversion triggers of the NPV rule. This effect can be explained because the ROA can consider opportunity costs over time in terms of the value of waiting to invest.

One relevant publication on the conversion to SRC is that of Musshoff (2012), in which he compares the conversion triggers of the NPV rule with those of the ROA relating to an example of a farmer who has set-aside land. Musshoff (2012) calculates that the conversion triggers following the ROA are considerably higher than those of the NPV rule. Therefore, a farmer following the ROA should be slower to convert to SRC compared to the NPV rule. He concludes that the ROA can partially explain farmers' inertia. As it is often done in real options applications, Musshoff (2012) ignores decision makers' disinvestment possibility as well as farmers' flexibility to reconvert the land used for SRC within its useful lifetime. If farmers follow the ROA, they sometimes may not be aware of their reconversion option. If so, their conversion triggers can be overestimated because they have a higher degree of flexibility in practice than farmers would believe and which is, for example, considered in the model of Musshoff (2012).

In this paper, we address the question of whether the ROA still can partially help to explain farmers' inertia if reconversion option is considered. Moreover, we aim to determine the influence of farmers' risk attitude on the conversion recommendation of the NPV rule and the ROA. Additionally, we evaluate the influence of an investment subsidy, which was offered to farmers in the UK, on the conversion recommendation of both approaches.

In our decision situation, we examine farmers' option of switching between traditional agricultural land use and SRC. We assume the land is of marginal soil qualities and a high groundwater level because SRC provides an interesting economic alternative on these soils. Since rye is usually cultivated on marginal soils for which other crops are not suitable (Bushuk, 2000), we compare SRC to rye production. We calculate conversion triggers at which farmers should convert from rye production to SRC following both the NPV rule and to ROA to allow for comparison. In the case of the ROA, we differentiate between conversion triggers with and without a reconversion option to evaluate the effect of a reconversion opportunity. We calculate reconversion triggers at which farmers should switch back from SRC to rye production. In the model applied, we make use of genetic algorithms (GA) and stochastic simulation. With the help of the GA, we can consider a high degree of entrepreneurial flexibility in the model. Using stochastic simulation we can model uncertainty in a very flexible way. This combination seems to be relevant for the determination of the optimal conversion and reconversion triggers. In our calculations we include different degrees of risk aversion to analyze its impact on the conversion and reconversion triggers. Moreover, we consider two stochastic variables for the gross margins (GM) of SRC and rye. Musshoff (2012) considers only one stochastic variable as the price for the harvested wood chips of SRC. If the land is not set-aside and economically interesting for agricultural crop production, it is necessary to include uncertainty concerning the prices and accordingly the GM of this alternative crop. Our model can capture the value of flexibility necessary to change production and farmers' inertia caused by risk aversion.

In the following section, we describe the decision problem and the methodological approaches. Thereafter, we mention the model assumptions and the data used. Afterwards, the results of our model are illustrated. Finally, the results are discussed and some conclusions are drawn.

Decision problem and methodological approach

In the first subsection, we describe the decision situation. We continue in the second subsection with the explanation of the calculation of the conversion triggers following the classical investment theory. In the third subsection, the ROA is generally explained, and the structure of the model to determine the conversion and reconversion triggers following the ROA is declared.

Description of the decision situation

We consider a farmer who has land with marginal soil qualities and no irrigation possibilities. The land has a higher groundwater level, which in contrast to annual crops can be used by SRC plants. These soils are particularly interesting for SRC (Murach et al., 2009) and is typical in some areas in the northeast of Germany. On these soils farmers usually cultivate rye. Therefore, the farmer in our model has the annual possibility to convert from rye production to SRC or to postpone conversion while further cultivating rye. We assume that through farmers' conversion decision there is no change in machinery equipment or labor.

If the farmer converts to SRC, investment costs occur at the beginning of each useful lifetime. In accordance with the governmental incentive that was offered in the UK, the investment costs are reduced by the amount of subsidy paid if the investment subsidy is considered. SRC generally has a useful lifetime, which often exceeds twenty years. Nevertheless, the farmer can reconvert the land within its useful lifetime and return to rye production. If he cultivates SRC until the end of each useful lifetime, the farmer has the opportunity to continue to convert to SRC further or use the land for rye production. At the end of each useful lifetime as well as in the case of a reconversion within the useful lifetime, recultivation costs occur. Due to farmers' possibility to cultivate SRC multiple times, we have to take into account an infinite period under consideration.

If the farmer converts to SRC, we assume that he cultivates poplar because it is a very promising wood fuel that achieves high yields and low input requirements (Nassi o di Nasso et al., 2010). In the case of SRC in general, and poplar in particular, the frequency between the harvests is dependent on the rotation period. In practice, if there is a rotation period of three years, the farmer receives conversion returns every third year. Moreover, the first