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Impact of perennial energy crops income variability on the crop selection of risk averse farmers

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HIGHLIGHTS

- ► Energy crop and conventional crop incomes suggested as uncorrelated.
- ► Diversification effect of energy crops investigated for a risk averse farmer.
- ► Energy crops indicated as optimal selection only on highest yielding UK sites.
- ► Large establishment grant rates to substantially alter crop selections.

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ABSTRACT

The UK Government policy is for the area of perennial energy crops in the UK to expand significantly. Farmers need to choose these crops in preference to conventional rotations for this to be achievable. This paper looks at the potential level and variability of perennial energy crop incomes and the relation to incomes from conventional arable crops. Assuming energy crop prices are correlated to oil prices the results suggests that incomes from them are not well correlated to conventional arable crop incomes. A farm scale mathematical programming model is then used to attempt to understand the affect on risk averse farmers crop selection. The inclusion of risk reduces the energy crop price required for the selection of these crops. However yields towards the highest of those predicted in the UK are still required to make them an optimal choice, suggesting only a small area of energy crops within the UK would be expected to be chosen to be grown. This must be regarded as a tentative conclusion, primarily due to high sensitivity found to crop yields, resulting in the proposal for further work to apply the model using spatially disaggregated data.

1. Introduction

Increased biomass use is expected to contribute to the UK's target to source 15% of energy from renewable sources by 2020 (DECC, 2009). To achieve these targets high growth rates are required in the biomass sector, both in the supply chain and biomass plant investment (Environment-Agency, 2009). The UK Biomass Strategy identifies the prospect of part of the increased supply coming from a major expansion of UK production in perennial energy crops, potentially using 350,000 ha, an area equivalent of 6.5% of total arable land (DEFRA, 2007). Despite the existence of financial incentives, the area of UK perennial energy crops established has so far been comparatively limited, at around 17,000 ha (RELU, 2009). The low uptake of these incentives promoted the grant rate to be increased from 40% to 50% of establishment costs (DECC, 2009).

There has been a number of studies to determine and model the biophysical properties of perennial biomass crops, as well as assessing the optimal spatial locations for production given biophysical constraints, such as temperature, soil and water limitations (Andersen et al., 2005; Aylott et al., 2008; Hastings et al. 2009; Price et al., 2004; Richter et al., 2008). Other research has applied environmental and socials constraints (Aylott et al., 2010; Lovett et al., 2009). A number of other studies have looked at the economic aspects of energy crops. Some have taken an estimate of the annual land rental charge to account for the foregone opportunity to make greater returns from other activities, or opportunity costs (Bauen et al., 2010; Monti et al., 2007; E4tech, 2009). The other approach commonly taken is to compare annual gross margins of conventional crops with an equivalent annualised value for the perennial energy crops (Bell et al., 2007; Styles et al., 2008; Turley and Liddle, 2008). Sherrington and Moran (2010) took a farm scale economic modelling approach to investigate the implicit potential uptake of perennial energy crops, optimising across activities to maximise gross margin. The results suggested that Miscanthus should have

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been adopted more widely, leading to support for perceived additional risks as a barriers to adoption.

Risk has often been cited as an important factor in farmer decision-making, with studies showing that farms typically behave in a risk-averse manner (Arriaza, 2003; Binswanger, 1980; McCarl and Spreen, 1996; Oglethorpe, 1995; Wallace and Moss, 2002). Comparing predictive capabilities of alternative models showed that models which exclude risk performed poorly (Arriaza, 2003). In the case of novel crops, representing risk has been identified as being of additional importance (Sherrington and Moran, 2010; Styles et al., 2008). However, to date analysis of energy crops choice including risk aversion does not appear to have been conducted.

This paper estimates the income variability of energy crops and their correlation to conventional crops using historic data. Farmer selection of perennial energy crops with a representation of risk aversion is then investigated using these data. The focus will be on Short Rotation Coppice (SRC) and Miscanthus, both dedicated perennial energy crops. The paper outlines an approach to integrate these novel crops, where the empirical data are unavailable. The significant factors in determining energy crop selection are investigated using a sensitivity analysis approach. Preliminarily conclusions are then drawn regarding the potential levels of economic growth of the energy crops in the UK, before future steps are proposed to apply the model to spatially and temporally disaggregated data within the UK, allowing maps of economic energy crop growth to be generated.

2. Method

2.1. Farm scale model

Farm scale economic modelling has a long history as a methodology to analyse decision-making, typically under conditions of competing choices for the allocation of limited resources subject to some optimisation criterion (Heady, 1954). This application represents decision-making in an arable farm type, where the optimisation criterion represents profit maximisation with constant absolute risk aversion.

The relevant arable activities, constraints and models were implemented using GAMS (General Algebraic Modelling Systems) (Brooke et al., 2010). No controlling and calibrating constraints or quotas not representing observable constraints where applied. McCarl and Spreen (1996) highlighted the danger of subjective constraints to "correct" model deficiencies. They give a "nominal" appearance of reality, but are actually causing the "right" solution to be observed for the wrong reason. Although rejecting such constraints may lead to models yielding excessively specialized solutions, the risk representation potentially provides for more complex and realistic behaviour. A positive mathematical programming (PMP) would provide certainty that the model could be calibrated to the observed data and be able to reproduce it (Howitt, 1995). PMP and other empirical approaches are in general not able to incorporate activities that are not within the observed base data (Arriaza, 2003). Therefore they were not appropriate for modelling of energy crops where their current novelty means sufficient observed data are unavailable. A normative mathematical programming approach was therefore selected.

An existing farm scale linear programme (LP) implemented in Microsoft Excel was taken as a starting point (Sherrington and Moran, 2010). The same approach was implemented to represent the nine conventional arable crops [winter wheat, winter barley, spring barley, winter oats, oilseed rape (OSR), sugar beet, peas, beans, and main crop ware potatoes], for multiple fertiliser application rates. Constraints were set on land availability and crop rotation. There were no fixed labour constraints, however all operations are charged at contract rates. This implies a disincentive to take on extra effort, including an allocation for machinery cost and fuel cost. Off farm income and single farm payments were not represented, as the absolute level of total farm income was not being investigated. It was assumed that the area was outside of a Less Favoured Area.

Expected incomes and costs were calculated using the current observed prices and rates. Evidence has been found that the single most significant farmers behaviour is associated with this price expectation (Brink et al., 1978; Chavas, 2000).

A risk representation was implemented in the model, using an expected income-standard deviation approach (Hazell and Norton, 1986). Perennial energy crops have a high initial establishment costs, with payback periods of many years. They are novel crops and the farmer is unlikely to have previous experience of them on which to base their decision-making. Both these points potentially lead to a higher perception of risk. In addition the market is less well developed than for conventional crops.

2.2. Data

The period 1990–2009 was used for the historic dataset. Historical time series data were for conventional crop prices and yields were from the Department of Environment Food and Rural Affairs (DEFRA, 2010). Prices, input rates, yields and contractor rates were taken from the SAC farm handbook 2009/10 (SAC, 2009). All prices were calculated in 2009 terms. The Office of National Statistics was used to obtain the inflation data using the "All Items" CPI inflation data (ONS, 2011). Energy price data were sourced from the Department of Energy and Climate (DECC, 2010).

2.3. Energy crops inclusion

2.3.1. Energy crop data

Comparisons of conventional annual crops with the energy crops have to take account that they are perennial. Both energy crops have a high cost of establishment that takes a number of years to pay back; but have long productive lifespans. Miscanthus is harvested annually, while SRC is harvested less frequently, typically every 3 years. All these aspects need to be factored into calculating a value that can be meaningfully compared to the gross margin on annual crops.

The energy crop data have been used to calculate an annual equivalent value (AEV), this represents an annual energy crop gross margin (Bell et al., 2007; Sherrington and Moran, 2010). The AEV produced can be compared to the gross margins derived for the conventional annual crops. The AEV is calculated by first present valuing all cash flows, by suitably discounting. The net present value of the crop is then annualised over the lifetime of the crop, using the sum of the discount factors for each year. This can be written as

$$AEV = \frac{\left(\sum_i^m p_i y_i f_i - \sum_j^n c_j f_j\right)}{\sum_k^n f_k} \quad (1)$$

where p_i is the energy crop price at the *ith* harvest of m harvests; y_i is the yield of the *ith* harvest; f_i is the discount factor for the *ith* harvest year; and c_j is the total of all costs in the *jth* year of n year crop life.

All future values were adjusted into 2009 terms using a 6% discount rate. All transactions were assumed to occur at the end of the year in which they occur. SRC plantations were assumed to be harvested every 3 years (Aylott et al., 2008). The total lifespan was taken as 21 years, or 7 harvests (Bauen et al., 2010). Miscanthus plantations where harvested annually starting in the second year, with a 16 years lifespan (Styles et al., 2008). For a given scenario,