Valuing the risk associated with willow and miscanthus relative to conventional agricultural systems

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Abstract— **The agronomic characteristics of willow and miscanthus make these crops highly susceptible to risk. This is particularly true in a country such as Ireland which has limited experience in the production of these crops. Issues such as soil and climate suitability have as yet to be resolved. The lengthy production lifespan of energy crops only serve to heighten the level of risk that affects key variables. The uncertainty surrounding the risk variables involved in producing willow and miscanthus, such as the annual yield level and the energy price, make it difficult to accurately calculate the returns of such a project. The returns from willow and miscanthus are compared with those of conventional agricultural enterprises using Stochastic Efficiency with Respect to a Function (SERF). A risk premium is calculated which farmers would need to be compensated with in order for them to be indifferent between their current enterprise and switching to biomass crop production. With the exception of spring barley, a risk premium is required if farmers are to be indifferent between their current enterprise and willow or miscanthus. The value of the risk premium required to entice farmers to switch to miscanthus production is significantly less than that required for willow. This suggests that a greater level of risk is associated with willow than with miscanthus.**

Keywords— **Biomass, SERF, Risk Premium**

I. INTRODUCTION

Despite being used as an energy source for centuries (Rosillo-Calle *et al.* 1999) [1], it is only recently that the potential of biomass as an alternative to fossil fuels has been examined. Environmental concerns (such as Greenhouse Gas mitigation), rising oil prices, security of supply issues, recent Common Agricultural Policy (CAP) reforms and rural development have been the key drivers of policy (Department of Communications, Marine and Natural Resources 2007) [2, 3] to increase the use of bioenergy in heat and power production in Ireland. In the recently published White Paper, the Irish government set a target of 30% of peat used for electricity generation to be replaced with biomass by 2015.

Clancy *et al.* (2008) [4] have used a farm-level optimisation model to estimate the price per GJ required in order to achieve these national co-firing targets under the assumption that all farmers are profit maximizers. However there is an element of risk associated with growing a relatively new crop such as willow or miscanthus compared with long established enterprises such as beef, sheep or cereal production, which was not captured by the farm-level optimisation model. The lengthy production lifespan of biomass crops only serve to heighten the level of risk that affects key variables. Farmers are generally a risk averse social group (Brink and McCarl 1978, Schurle and Tierney 1990) [5, 6] so given the uncertainty that exists over biomass yields, a value for the risk of adopting biomass crop production was calculated. This could be added to the profit maximising price per GigaJoule (GJ) required to achieve national co-firing targets calculated by Clancy *et al.* (2008) [4].

II. MATERIALS AND METHODS

The analysis presented in this paper is based on the results of a crop costings model and a risk ranking procedure known as Stochastic Efficiency with Respect to a Function (SERF) (Richardson *et al.* 2000) [7]. The data for the crop costings model was provided by the Teagasc Crops Research Centre, Oakpark, and was used to calculate the baseline economics of willow and miscanthus (see Clancy *et al.* 2008 [8]). The crop costings model also used projected costs from the FAPRI-Ireland aggregate level commodity model (Binfield *et al.* 2007) [9]. Willow and Miscanthus are both perennial crops and so the gross margins for both crops are calculated on a net present value (NPV) basis. From this NPV an annual equivalent value was calculated and used to compare the two crops with conventional agricultural systems. All costs and prices were calculated on a per hectare basis.

A range of values for the prices and costs associated with conventional agricultural enterprises were taken from the National Farm Survey Enterprise Analysis (Teagasc 2007) [10]. These 2006 prices and costs were then inflated forward to 2008 using FAPRI-Ireland model projections and a gross margin for 2008 was calculated; thereby accounting for the recent trend of higher cereal and milk prices. A probability distribution of the gross margins from each enterprise was then calculated. This was then stochastically simulated using the Microsoft Excel add-in SIMETAR (Simulation and Econometrics to Analyze Risk). SERF was then used to calculate a certainty equivalent for each enterprise. This is a risk premium which shows the amount of money that a decision maker would have to be paid to be indifferent between two competing enterprises. The enterprises examined were Dairy, Beef 1 (Single Suckling Calves to Finish), Beef 2 (Stores to Finish), Sheep, Cereals 1 (Winter Wheat), Cereals 2 (Spring Barley), Willow and Miscanthus.

According to expected utility theory, the decision maker's utility function for outcomes is needed to assess risky alternatives as the shape of this function reflects an individual's attitude to risk (Hardaker *et al.* 2004) [11]. In practice however, this rarely holds true. Efficiency criteria allow some ranking of risky alternatives when the preferences for alternative outcomes of decision are not exactly known (Grove 2006) [12]. Stochastic Efficiency with respect to a function is a method used to rank risky alternatives. Lien *et al.* (2007) [13] used SERF to measure the risk efficiency of two alternative farming systems (organic and conventional farming systems) in terms of the probability distribution of current wealth from farming, defined as the NPV of farm equity at the end of the planning horizon. SERF was also applied to analyze optimal farm strategies (tree planting on harvested land) for a specified range of attitudes to risk (Lien *et al.* 2007) [14]. This method lends itself to analysis of biomass crop production in Ireland where data on individual farmers risk preference is limited.

III. RESULTS

Clancy *et al.* (2008) [4] found that government co-firing targets could be achieved at a price per GJ of €7.20. This however does not take account of the risk faced by the farmer in switching to an enterprise in its pioneer stage in Ireland. The results for a normal risk averse group of producers are presented below in Figure 1 and Figure 2. A risk premium necessary for a farmer to be indifferent between willow and miscanthus and their current enterprise per GJ of energy produced was calculated. Dairy farmers are excluded from the graphs due to the significantly higher risk premiums they would need to be paid to adopt willow (€15.44) and miscanthus (€11.37).

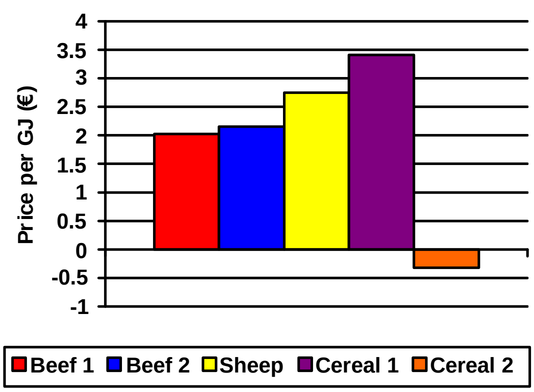

Figure 1: Risk premium required for willow per GJ of energy produced

Dairy is by far the most dominant enterprise and the high value attached to the risk of switching from this system to willow or miscanthus makes it unlikely that it will occur. Until now the biggest obstacle to expansion on Irish dairy farms has been the availability of milk quota. However, with the prospect of milk quota abolition in 2015, it is unlikely that Irish dairy farms will switch land from dairy production to the production of biomass crops.

The risk premiums for each enterprise in Figures 1 and 2 could be added to the profit maximising price per GJ required to achieve national co-firing targets calculated by Clancy *et al.* (2008) [4]. For example, if Clancy *et al.* (2008) [4] have estimated that the optimal price at which Irish farmers would be better off growing miscanthus to be €7.20, then a calf to finish farmer would need an additional risk premium of €0.57 in order to offset the risk associated with switching enterprises. Therefore a price of €7.77 would be required to achieve the targets.

With the dairy enterprise excluded, winter wheat farmers require the highest risk premium to switch to willow (€3.41) and miscanthus (€1.70) production. This reflects the effect that the high cereal prices currently on offer have on the gross margins for this enterprise. Sheep farmers require the next largest risk premium (€2.75 for willow and €1.16 for miscanthus) with the two beef enterprise farmers requiring similar levels for willow (€2.02 for Beef 1 and €2.15 for Beef 2) and miscanthus (€0.57 for Beef 1 and €0.68 for Beef 2). The analysis suggests that farmers engaged in spring barley production would not require a risk premium to switch to willow (- €0.32) and miscanthus (- €1.31). This is largely due to the on average low yields attained by the bottom 25% of farmers growing spring barley.

The risk premium is on average higher for willow indicating that it is a riskier investment than miscanthus. Although willow has a longer production lifespan than miscanthus, it fails to generate the same level of returns. This is in part as a result of willows multi-year harvest cycle, which takes longer to produce a positive net value in comparison to miscanthus with its annual harvest cycle.

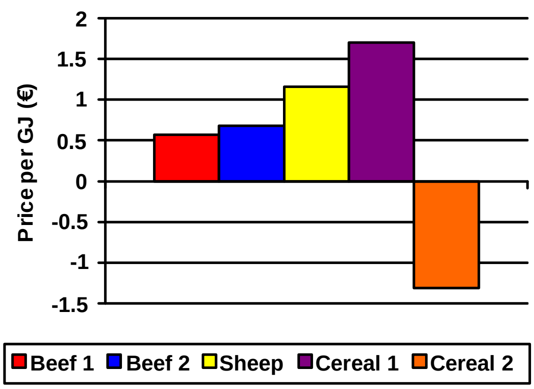

Figure 2: Risk premium required for miscanthus per GJ of energy produced

The length of the harvest cycle also likely contributes to the lower level of risk associated with miscanthus. An annual income stream as opposed to a lump sum every two to three years would help reduce the variability in project returns. The reduction of the harvest cycle length for willow is seen as fundamental in making it competitive with both conventional agricultural enterprises and miscanthus. Better crop management techniques developed as expertise in the area grows could potentially increase yields between harvest cycles, decreasing risk significantly.

IV. DISCUSSION

There is also institutional risk involved in the production of biomass crops. This stems from the policy framework currently in place in Ireland. For example, the level of subsidies at present is not guaranteed beyond the short term, further reducing the ability to predict the economic viability of biomass crop production projects. The bioenergy market in Ireland, still at a pioneer stage, suffers as a result of this inherent riskiness. The uncertainty manifests itself in a reluctance to enter both the supply and demand side of the market. The low biomass crop adoption levels in recent national farm surveys highlight this point.

This paper found that accounting for risk underlined the results of the baseline economics from Clancy *et al.* (2008) [8]. They found that under given assumptions and costings, miscanthus was found to have a greater level of returns than willow. The sensitivity analysis they conducted on the key variables also showed miscanthus to be a superior investment. Miscanthus was found to be less susceptible to risk while boasting greater returns. The results from this SERF analysis tell a similar tale with miscanthus having a lower risk premium than willow.

V. CONCLUSIONS

The uncertainty surrounding the risky variables involved in producing biomass crops, such as the yield level and energy price, make it difficult to accurately calculate the returns of such a project. In turn this risk will hinder the growing of an area large enough to meet national co-firing targets. A risk premium in conjunction with the profit maximising price calculated by Clancy *et al.* (2008) [4] could therefore provide the necessary incentive for a sufficient number of farmers to adopt willow or miscanthus production in order to achieve national co-firing targets. However, it should be stated that even with this combination of a profit maximising price and an additional risk premium, there will be some farmers who would be better off switching enterprises but wont due to demographic or personal characteristics. These are factors which we don't fully capture in our analysis but which cannot be ignored either.

With the exception of spring barley, a risk premium is required for all enterprises examined if farmers are to be indifferent between their current enterprise and willow or miscanthus. The value of the risk premium required to entice farmers to switch to miscanthus production is significantly less than that required for willow. This suggests that a greater level of risk is associated with willow than with miscanthus.

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Fig. 1 EAAE logo

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