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Modelling the costs of energy crops: A case study of U.S. corn and Brazilian sugar cane

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This paper describes a simple probabilistic model of the costs of energy crops. This forward-looking analysis quantifies the effects of production constraints and experience on the costs of corn and sugar cane, which can then be converted to bioethanol. Land is a limited and heterogeneous resource: the crop cost model builds on the marginal land suitability, which is assumed to decrease as more land is taken into production, driving down the marginal crop yield. Also, the maximum achievable yield is increased over time by technological change, while the yield gap between the actual yield and the maximum yield decreases through improved management practices.

Our model focuses on the marginal cost of producing crops, i.e. the cost of producing crops on the marginal hectare of land at a given time. The marginal production cost is relevant as it will reflect the costs faced by land-renting farmers on every type of land under cultivation at that time. These farmers will encounter the specific cost of production associated with the suitability of the land they cultivate plus the rent owed to the landowner. In total, every crop-producing farmer will therefore face the cost of producing crops on the marginal hectare of land.

Both technological advances and the limited supply of land are driving the supply of crops and both need to be taken into account to forecast future crop costs. Land is heterogeneous and of limited supply, and it is economically rational to use the low cost, high quality resources first. With a given state of knowledge and experience, every farmer will see increasing costs of production. Learning is introduced through the use of three parameters: the learning rate associated with developments in biotechnology and increasing the maximum achievable yield, the learning rate associated with better management practice and affecting the yield gap, and alpha the rate of general

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technical progress across the economy. Uncertainty is introduced by assigning a distribution to each parameter, and a literature review is conducted in order to define ranges of estimates.

The results show large uncertainties in the future costs of producing corn and sugar cane, with a 90% confidence interval of 2.9 to 7.2 $/GJ in 2030 for marginal corn costs, and 1.5 to 2.5 $/GJ in 2030 for marginal sugar cane costs. The influence of each parameter on these supply costs is examined.

In the case of US corn, experience and technological developments are driving down the marginal costs in the first half of the period. As more land is used, the decreasing suitability of land overtakes experience, and marginal costs increase until the total amount of suitable land is used in 2045. When all suitable land is used, marginal costs are mainly influenced by learning. The three learning parameters are gaining influence on costs over time. The total amount of suitable land affects the onset of the decreasing suitability of the marginal land: its influence peaks in 2040.

In the beginning of the period, higher demand drives the decreasing suitability of the marginal land. As the maximum achievable yield comes closer to its minimum value, the potential for further cost increase is reduced, and the influence of demand growth decreases: the effect of learning is slowly overtaking the effect of the decreasing suitability of the marginal land.

In the case of Brazil, the marginal costs show the same pattern as U.S. corn costs. However, the peak of the influence of the demand parameter is reached later than in the case of corn. This shift is explained by the fact that the total amount of suitable land is used up earlier for the U.S.

In future work, a model for conversion costs will be introduced: the costs of producing ethanol will be calculated from the costs of crop and the conversion yield, driven by accumulated experience. The cost of carbon will be considered when assessing the cost-competitiveness of these fuels. Carbon emissions from crop production and conversion stages will be assessed, and the social cost of carbon will be used to calculate the total carbon costs associated with ethanol production from U.S. corn and Brazilian sugar cane. The costs of supplying ethanol will be later compared to the costs of petrol from non-conventional fossil resources, including learning, depletion and carbon costs.

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