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Landowner willingness to supply marginal land for bioenergy production

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ABSTRACT

This study elicits willingness to supply marginal land for biomass cultivation in Southern Lower Michigan. Most of the surveyed landowners are not interested in renting land for bioenergy crop production. Those who are interested offer relatively little land for bioenergy crops, even at rental rates three times current levels. Willing landowners would prefer to grow a significant portion of these crops on cropland rather than non-crop, marginal land. Hence, the area of marginal land that owners are willing to supply for bioenergy crop production falls far short of area estimates based on remote sensing that ignore landowner preferences.

1. Introduction

Despite being a renewable fuel that is potentially carbon neutral, ethanol has raised concerns that policies intended to promote it may also raise food prices and trigger indirect land use effects that accelerate climate change (Rajagopal et al., 2007; Searchinger et al., 2008; Dumortier et al., 2009). Ethanol can be produced either from starch- and sugar-based feedstocks or from cellulosic feedstocks. Starch- and sugar-based feedstocks come overwhelmingly from corn grain and sugarcane, both important food and feed sources. Cellulosic feedstocks may come from the inedible parts of food crops (e.g., corn stover and sugarcane bagasse) or from dedicated biomass crops (e.g., switchgrass). Policies that augment demand for bioenergy feedstocks from edible parts of food crops directly raise food prices (Rajagopal et al., 2007; Dumortier et al., 2009). Policies that raise demand for cellulosic feedstocks do not increase food prices directly, though they may do so indirectly by competing with food crops for cropland and other productive resources (Searchinger et al., 2008). While cellulosic ethanol remains costly to produce, the intensive scientific search for cost-effective ways to process cellulosic feedstocks into ethanol prompts the need to understand the likely repercussions of growing such feedstocks at large scale.

In theory, food price feedbacks and attendant indirect land use effects from biofuel policies could be avoided if the production of cellulosic feedstocks did not reduce food supplies. Avoiding such competition could occur by increasing output of cellulosic feedstocks either by intensification of byproduct crops or by extensification of dedicated cellulosic biofuel crops. In the United States, intensification of corn production on current crop land would entail raising output of stover and cobs as byproducts for cellulosic ethanol. However, even if this could be done without changing the flow of corn grain to the grain ethanol market, this increased demand for corn land would trigger indirect land use effects through reducing the supply of cropland for other crops (Ciaian and Kancs, 2011). Extensification would mean expanding cellulosic biomass production onto land at the extensive margin. By occupying land that is not used for crops, bioenergy crop production on marginal land could mitigate competition for cropland and associated upward pressure on food prices (Campbell et al., 2008; Carroll and Somerville 2009; Swinton et al., 2011).

The existing literature on the availability of non-crop marginal land ignores landowner willingness to supply land, focusing chiefly on biophysical production potential. Cai et al. develop a global estimate of land availability using remotely sensed land cover data (Cai et al., 2010). Gelfand et al. (2013) also use remote sensing with vegetation modeling to identify eleven million hectares of marginal lands in the US Midwest where native vegetation would be

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sufficient to meet one-quarter of biomass needs to meet the national cellulosic ethanol target set by the US Energy Independence and Security Act of 2007. Another relevant current of literature in agricultural economics uses optimization models to project the potential supply of land for bioenergy crops as a function of available cropland and some percentage of non-crop land (Khanna et al., 2011). Such studies assume that landowners would treat non-crop lands as they do cropland. While certainly more plausible than the 100% land availability assumption implicit in the remote sensing studies, these economic projections still lack empirical evidence on landowner willingness to make non-crop lands available for bioenergy crops.

There is a growing literature that assesses landowner willingness to grow energy crops on cropland. Cope et al. (2011) examined farmers' willingness to grow perennial energy grasses in central Illinois and reported that around one third of the surveyed farmers were willing to adopt these energy crops. A similar study from Illinois shows that 24 percent of the questioned landowners were willing to grow bioenergy crops (Villamil et al., 2012). In a study assessing Swedish farmers' willingness to allocate land for energy crop production, Paulrud and Laitila (2010) noted that expected net income and the crops' growing characteristics affect farmers' adoption decisions. Jensen et al. (2007) investigated Tennessee's farmers' willingness to grow switchgrass and reported a lack of knowledge among many of the surveyed farmers on growing this crop for energy. The same study found that around 30 percent of the surveyed farmers were willing to adopt switchgrass for energy production. Mooney et al. (2015) employed a contingent valuation (CV) approach to investigate farmers' willingness to grow bioenergy crops on marginal lands in Southwest Wisconsin. Their findings show that marginal lands for bioenergy production are scarce and costly and potential spatial agglomeration of bioenergy production could arise.

In short, there are two major literatures on the supply of land for bioenergy crops. One looks at the theoretical supply of non-crop marginal land while ignoring human land use decisions. The other looks at the supply of cropland and includes farmers' expressed intentions. In between, there lies an important gap of knowledge regarding the amount of non-crop marginal land that could be supplied for energy biomass. As already documented by remote sensing studies (e.g., Cai et al., 2010; Gelfand et al., 2013), that total area is large. The unanswered question is how much non-crop land its owners would choose to make available for bioenergy crop production. This study answers that question by examining the economic availability of non-crop, marginal land to grow bioenergy crops through eliciting the willingness of all owners of marginal land to supply this land for bioenergy production. The study explicitly incorporates key price variables (rental rates) to derive supply functions for bioenergy crops from marginal lands. Looking at four major bioenergy crops across three land use categories, it examines the conditions for making each land category available, and the amount of land these landowners would be willing to make available for bioenergy crops. It further investigates the underlying factors that drive decisions to make land available for energy crops.

2. Methods and data

2.1. Conceptual model

Landowners are assumed to maximize utility that is derived from consumption of both marketed products and amenities that come from land (Lopez et al., 1994; Brunstad et al., 1999; Deaton et al., 2007). Marketed products must be purchased with income that can come from a variety of sources such as salary, wages, social security, rental properties, investments, or any other monetary generating source. Amenities from land can take a variety of forms, such as scenery, hunting, fishing, recreational vehicle use, or other physical activities. Following Dupraz et al. (2003) and Ma et al. (2012), the utility maximization problem for a landowner in the case of biomass crop production is as follows:

$$\mathrm{Max}_{\mathrm{LU}^U} = U[a, c] \tag{1}$$

s.t.

$$c = r_{\mathrm{land}} + r_{\mathrm{other}} \tag{1a}$$

$$a = a_{\mathrm{land}} + a_{\mathrm{other}} \tag{1b}$$

In Eq. (1) utility (U) is a function of amenity values a, and expenditure on consumption goods c that is maximized over the land use decision (LU). A landowner maximizes utility subject to a consumption constraint (composed of land income (r_{land}) and income from other sources (r_{other}) and the availability of amenities from land (a_{land}) and other sources (a_{other}). Growing bioenergy crops can affect both income and amenities from land. Landowners will maximize utility from land by equating individual preferences for income and amenities from land given land resource constraints. Income from land and amenities from land are both functions of land use:

$$r_{\mathrm{land}} = f(\mathrm{LU}) \tag{2}$$

$$a_{\mathrm{land}} = g(\mathrm{LU}) \tag{3}$$

A change in land use ΔLU results in a change in income from land (Δr_{land}) and therefore consumption Δc as well as a change in amenities from land (Δa_{land}). Changes in consumption and amenities affect utility so the decision to change land use will cause a net change in utility. Equation (4) shows the base case utility and Eq. (5) the utility after a change in land use:

$$U_0 = U[c_0, a_0] \tag{4}$$

$$U_1 = U[c_0 + \Delta c, a_0 + \Delta a] \tag{5}$$

A landowner decides to change land use (ΔLU = 1) if utility after the change is greater than the utility in the base case:

$$\Delta\mathrm{LU} = \begin{cases} 1 \text{ if } U_0 < U_1 \\ 0 \text{ otherwise} \end{cases} \tag{6}$$

When this conceptual model is applied to the case of growing bioenergy crops on marginal land, an individual landowner may or may not convert the land depending on the income and amenities received from it. While growing the bioenergy crops may prove to be profitable on marginal land and thus raise the income of landowners, the extra consumption made possible may not provide greater utility than the amenities the land provides when it is not in use for bioenergy crops. In this case, a utility maximizing landowner would not change land use despite a potential income increase.

Empirically it may be difficult to observe all consumption tradeoffs. However, the foregoing conceptual model implies that land use decisions will depend upon (i) land-based income $\mathrm{r}_{\mathrm{land}}$, a function of land management and uses m, (ii) relative prices (i.e., rental rates and contract length) p, and (iii) amenities a, given a set of heterogeneous attitudes and demographic variables, z:

$$\mathrm{LU}_{ij} = h_i(\mathrm{r}_{\mathrm{land}}, m, p, a_{\mathrm{land}}|z) \tag{7}$$

where LU_{ij} is the supply of land in use j by each landowner i, subject to land area availability in each land use category.