Energy Economics 47 (2015) 1–10

Contents lists available at ScienceDirect

Energy Economics

journal homepage: www.elsevier.com/locate/eneco

# Willingness to supply biomass for bioenergy production: A random parameter truncated analysis

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ARTICLE INFO

*Article history:*
Received 20 May 2013
Received in revised form 24 October 2014
Accepted 25 October 2014
Available online 3 November 2014

*JEL classification:*
D2
D4
Q1
Q2
Q4
L7

*Keywords:*
Biomass
Willingness to supply
Bioenergy
Price

ABSTRACT

This paper presents research results based on data from two biomass producer surveys collected from mid Missouri and southern Illinois. A series of random parameter truncated regressions are utilized to analyze willingness to supply results under three price scenarios. Marginal effects suggest that producers will supply an additional 1.6 to 2.4% of their biomass production for each one dollar increase in price and that supply for three types of biomass (stover, straw and hay) is elastic. This means commercial developers that are interested in pricing biomass and policy makers considering subsidies could expect modest supply responses for each dollar increase in price.



## 1. Introduction

Bioenergy and other industrial products produced from agricultural biomass have increasingly become the focus of both physical and social science research where there are numerous research perspectives. For example, the physical characteristics, processing technologies, environmental consequences and potential volume of biomass have been studied. As technologies near commercialization economic perspectives become paramount.

Among the economic topics, the biomass producers' willingness to supply is critical to the commercialization process and ultimately the feasibility of the industry, regardless of the specific technology considered. Thus, the purpose of this paper is to investigate the impact of price variability and producer characteristics on agricultural producers' willingness to supply biomass (straw, corn stover and hay) to emerging biomass-based industries. These industries include biopower and biorefineries, where a range of additional products can be produced such as cellulosic ethanol. This article relies on local primary data collected in separate surveys in mid Missouri and southern Illinois, two areas with highly productive agricultural land usually planted to traditional agricultural crops, such as corn and soybeans.

In this paper we analyze biomass producer responses to new bioenergy industries. The demand for products such as cellulosic ethanol, biopower and other final bio-products will increase the demand for the raw material, necessitating the development of these new supply chains. The biomass producer responses we focus on include the willingness to supply biomass, the services (i.e. harvest, transportation, storage services) they may be willing to provide and their current physical assets that could be used to support new biomass-based industries. A key focus will be on how price and other producer specific factors influence their willingness to supply.

One of the key variables in any feasibility study is the degree to which biomass producers will respond to price incentives to supply their products. Further from a policy perspective, subsidies, other price controls, and investment incentives on either the biomass itself or the final product could stimulate biomass industries. This study will reveal and analyze what proportion of their biomass producers are willing to supply under three different price scenarios while also taking into account other pertinent producer socio-economic and farm characteristics. Price impacts on the willingness to supply could be interpreted

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http://dx.doi.org/10.1016/j.eneco.2014.10.016
0140-9883/

from a feasibility study or policy perspective. The analysis utilizes a series of random parameter truncated regression models motivated using random utility models to measure the role of price and other producer characteristics in increasing the supply of biomass.

## 2. Literature review

A key area of research in the biomass and bioenergy literature is technological feasibility studies that analyze and compare the costs of bioenergy process technologies. The various general process technologies include: biological, chemical, thermal and physical processing of biomass (Brown, 2003), or some combination of these processes. In the mid-1990s biological pathways such as enzymatic hydrolysis proved to be cost competitive with corn ethanol and more environmentally sustainable than leading chemical path ways using acidic hydrolysis (Lynd, 1996 and Wyman, 1994). Physical processes have been shown to be most effective in pretreatment stages followed by biological, chemical and thermal processes for final conversion of the biomass. Thermal processes tend to be more mature technologies and are the basis of the current biopower industry (Altman and Johnson, 2009).

Even with the technological advances in biological and chemical processes the emergence of a cellulosic fuel industry has lagged behind corn ethanol (Altman et al., 2010). For the most part, growth in cellulosic industries has been limited to demonstration facilities subsidized with public funding. Further, policies in the U.S. and worldwide could increase incentives to develop cellulosic industries. For example, the 2007 Energy Independence and Security Act, mandates extensive expansion of renewable energy alternatives, such as cellulosic ethanol production. This expansion will in part likely come from biomass sources such as straw and stover, which may become more important if gasoline blending rates increase in the future (De la Torre Ugarte et al., 2007; Epplin et al., 2007).

Non-technical barriers to development of cellulosic industries are also important questions to consider in addition to technological questions. Among these, logistics, market organization and producer willingness to supply questions are the most relevant. Altman and Johnson (2009) investigate organizational structure of current U.S. biopower industry while Altman et al. (2007a) consider the impact of scale on organizational decisions in that mature biomass industry. Supply chain development, an oft-overlooked aspect of biomass industries — is considered by Altman et al. (2007b), who also find that the nature of supplier contracts may also impact the development of the cellulosic ethanol industry (Altman et al., 2008).

While the physical quantity of potential biomass available is an important factor in the feasibility of bioenergy production (Klass, 1998), in this paper we consider the broader willingness and ability of producers to supply cereal straw, corn stover and surplus hay to hypothetical bioenergy processors. In more aggregated state level analysis, Gallagher et al. (2003), take an indirect approach to modeling producer's costs of production in various regions and estimate the prices needed by producers to cover their opportunity costs. Other indirect approaches model the profitability of producers for typical farms if they convert to biomass production under various assumptions such as risk and contract type (Larson et al., 2008). The contract/organizational approach is more the focus of other research (Altman et al., 2013; Bergtold et al., 2014); here we broaden discussion and analyze direct local data and compare willingness to supply responses of producers in two regions, mid-Missouri and southern Illinois, and at different potential price levels. In addition, we get an indicator of the assets and services producers may be willing to provide, to serve the new bioprocessing facility, to understand the ability of producers in order to actually supply the biomass.

Industries based on first generation biofuel produced from corn and soybeans have matured over the last ten years. The costs of bioproducts from cellulosic sources will invariably depend on the cost of the underlying biomass feedstock. We focus on second generation biomass, corn stover, cereal straw and low protein grass hay, that farmers are currently producing but not necessarily selling every year. Farmers who do not currently sell their biomass may keep it for agronomic purposes (soil fertility and structure) or as a feed source (grazing and hay) or bedding materials for livestock. While it is not the focus of this paper, these uses of the biomass represent farmers' opportunity costs and prices offered for biomass will have to at least cover these opportunity costs. Other research considers producers' willingness to convert land to third generation energy crops like switch grass and miscanthus (Jensen et al., 2007), in this article we focus on potentially more available second generation biomass.

While there is much research investigating technological feasibility, willingness to supply topics still remain under-researched. Unlike traditional starch to ethanol, from corn, where well developed supply chains existed before corn ethanol industries developed, biomass supply channels will have to develop in order for there to be successful commercialization of new cellulosic conversion technologies. Willingness to supply research is critical in the early stages of commercialization of new technologies and industry development.

## 3. Survey data

The data set for this study originates from separate mail surveys of producers in mid Missouri and southern Illinois conducted by the Southern Illinois University and the University of Missouri. The Missouri survey was administered in January and February 2007, while the Illinois survey was administered in January and February 2009. Both surveys were similar in structure, covering production practices, assets and activities, marketing, and demographics. Survey procedures were also similar; producers were mailed a survey in January followed by a reminder postcard and a replacement/reminder survey two weeks later in early February. Survey procedures followed those outlined by Dillman (2007). This procedure was followed to allow biomass producers time to respond when they were expected to be the least busy with their farming operations.

The surveys were mailed to 2500 producers in Missouri and 3000 producers in Illinois based on a random sample of farms from the list managed by the USDA, National Agricultural Statistics Services (NASS). Producers were randomly selected from those who reported producing hay, corn and/or cereals. About 600 producers responded to the Missouri survey and about 960 to the Illinois survey for a response rate of 24% and 32%, respectively. These response rates are similar to other mail surveys administered by USDA-NASS in the study region. Some producers who responded to the survey did not complete the entire survey and/or did not provide consistent responses to questions that were used to derive the dependent and explanatory variables used in the model. These survey responses were summarily removed from the sample.

Asset variables were attained by asking producers whether they currently owned various assets like balers, and trucks and trailers for biomass transport while service variables were gathered by asking producers if they would be willing to provide services such as biomass harvest, storage and transport. Producers were asked about their percentage of biomass they would be willing-to-supply of cereal straw, corn stover and hay for a typical year considering weather, soil structure and fertility under 3 different expected pricing scenarios: $10, $15 and $20 per dry ton, priced in the field (not baled). Demographic and farm characteristic variables such as age, farm income, amount of land rented, education level achieved, and crop acreages were collected, as well. Summary statistics for the variables collected and used in the study are provided in Table 1.

Comparing the summary statistics in Table 1 to summary statistics derived from the 2012 Agricultural Census (USDA-NASS, 2014) provides some indication of the nature of the sample of producers being examined compared to the entire farm population. The statistics used