Energy Policy 69 (2014) 598–609

Contents lists available at ScienceDirect

Energy Policy

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

The regional effects of a biomass fuel industry on US agriculture

Paul W. Gallagher *,[1]

Department of Economics, Iowa State University, 481 Heady Hall, Ames, IA 50010, United States

HIGHLIGHTS

- We look at the potential competitiveness of a mature biomass fuel (BF) industry in the US.
- We model a land policy that allows BF-cattle competition for forage, crop residues, and pasture.
- We estimate the cost reductions and welfare gains associated with modifying the land use policy.

ARTICLE INFO

Article history:
Received 2 November 2013
Received in revised form
20 February 2014
Accepted 24 February 2014
Available online 24 March 2014

Keywords:
Advanced biofuels
Regional agriculture impact
US land use policy

ABSTRACT

This study looks at the potential competitiveness of the emerging biomass-based biofuel industry in the current economic environment. A simulation model suggests that a mature biomassbased biofuel industry is potentially competitive with gasoline, and capable of filling a significant fraction of motor fuel supplies. However, the existing land policy has a narrow definition of agricultural land for a biomass-based fuel industry. A broader definition of agricultural land suitable for biomass inputs would reduce biofuel processing costs, relieve the food versus fuel conflict, and increase the net gain to fuel consumers, food consumers, and producers of food and fuel.

1. Introduction

Past discussions of a possible biomass fuel (BF) or biomass ethanol (BE) industry focused on the dominant bottleneck—the absence of a viable processing technology.[2] But commercial scale processing facilities are emerging now. For instance, an 11 MGY plant similar to a petroleum refinery in Mississippi and an 8 MGY gasification-ethanol plant in northern Florida have already produced some output and obtained Renewable Inventory Number (RIN) certificates from the United States Environmental Protection Agency that certify plant output for use in the US biofuels program (Cannon, 2013; Williams, 2013; Federal Register, 2013, p. 9293). Further, two fermentation-ethanol facilities are in the visible stage of plant construction in Iowa (Panoutsou et al., 2013). The argument is shifting away from the technical feasibility of processing technology, and towards other issues relevant to technology adoption.

This paper addresses issues that are relevant to BF industry development today. First, we show that a BF industry could be competitive in today's energy markets if the processing industry development continues. Also, we present simulations suggesting that the size of the potential BF industry could be substantial. Finally, we show that industry location, competiveness and potential for food vs. fuel tradeoffs depend on modifying existing land use regulations in the RFS2 towards something more compatible with the BF industry. Regarding organization, we first discuss the conceptualization of biomass supply in the context of the resource markets of US agriculture, and review a formal model of biomass supply at the state level. Then we describe the characteristics of a baseline for US agriculture and energy markets that reflects today's market environment. Thereafter, we summarize our simulation results and draw conclusions.

* Tel.: +1 515 294 6181.
E-mail address: paulg@iastate.edu

[1] The author was on leave during the project reported here, and was stationed at: The Office of Energy Policy and New Uses/Office of the Chief Economist, U.S. Department of Agriculture, Washington, DC 20260, United States.

[2] *Abbreviations*: Biomass Fuel (BF), biomass ethanol (BE), Million Gallon per year (MGY), renewable inventory number (RIN), Renewable Fuel Standard, phase 2 for biomass (RFS2), billion gallons per year (BGY), Bureau of Land Management (BLM), US Forest Service (USFS), US Department of Agriculture (USDA), high fructose corn syrup (HFCS).

Some States of the US: AL (Alabama), AR (Arkansas), FL (Florida), GA(Georgia), IA (Iowa), IL (Illinois), IN (Indiana), KS (Kansas), KY (Kentucky), LA (Louisiana), MI (Michigan), MN (Minnesota), MO (Missouri), MS (Mississippi), ND (North Dakota), NE (Nebraska), OH (Ohio), OK (Oklahoma), SD (South Dakota), TN (Tennessee), TX (Texas), VA (Virginia), WI (Wisconsin).

http://dx.doi.org/10.1016/j.enpol.2014.02.037
0301-4215/

2. Material and methods

2.1. Market relationships

The new demands on the land and crop residue markets from the BF industry will emphasize woody (cellulose like) materials, instead of the carbohydrate and protein rich materials demanded in food markets. Essentially, US agriculture will now have two (woody) biomass processing industries instead of one. Heretofore, cattle were the primary animal capable of digesting grasses, crop residues, and other wood-like materials that otherwise had limited value in agricultural markets.

Hence, this analysis begins with the assumption that the BF industry will compete in the local land and forage markets. There are two types of enterprises bidding for the use of the agricultural land inputs: cattle producers and crop producers. Crop producers face given international (output) prices for corn, soybeans, and wheat. They bid to use land input for crop production in the local rental market. Cattle producers face given international prices for beef and milk. They rent land for grazing and hay production in the local rental market.

The main markets are local. Local crop producers bid for nearby land according to their derived demand for corn, soybean and wheat production. Local cattle producers bid for land according to their derived demand for hay, pasture (grazing) land, and crop residues like corn stover. Land cannot be moved. For residues and hay, prices are given mainly in rural newspapers and signs at farm boundaries, and transport occurs in pickup trucks or flat bead trailers around a locality.

Given that the BF and cattle industries use inputs with the same grassy/woody characteristics, estimation of sustainable biomass supplies should include the regional dynamics of cattle population. Furthermore, beef and milk both have declining markets, especially in the central, southern, and eastern parts of the US. Nationally, the declines in cattle forage demand are large, 100 million tons since 1975, and are a potentially large supply of biomass to the BE industry. In fact, the magnitude of forage declines is comparable to estimates of corn residues that could be available for biomass. Regionally, some areas are exiting the cattle industry, while other competitive areas are still maintained (Fig. 1). Further, pasture accounts for about half of the forage input of cattle, so declines in cattle forage could be key to explaining why a US BF industry could grow.

2.2. Model

The simulation model reflects market relations of the land and forage markets. We added cost and supply relationships for biomass crops, residues and biomass fuel processing to an existing model of commercial farmland use. Also, a new dynamic analysis of cattle population and forage demands is included. Similar local market models are specified for 25 states in the Midwest, South and East sections of the US that have high biomass supply potential. In turn, a graphical statement, the empirical foundation, and the equations of the model are presented.

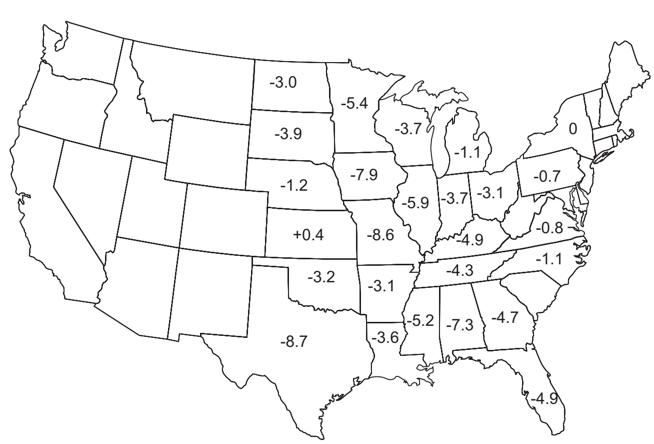

Fig. 1. The decline in cattle forage demand (1975–2009) by state (million tons).

The farmland model reflects supply and demand for land use and forage in local markets around the United States. Fig. 2 summarizes equilibrium in cropland and grazing land markets before energy crops are introduced. For cropland (Fig. 2a), demand includes use for food and feed crops (Cd in panel iii) and conservation (*Cz* in panel iv). The Cropland rental market equilibrium of Fig. 2a occurs at R_c° (panel ii) where the sum of demands, $Cd+Cz$, intersects the perfectly inelastic supply of cropland, *Lc*. For grazing or pasture land (Fig. 2b), supply includes pasture land supply (*Gs* in panel iii) and cropland supply for pasture use (*Cg* in panel iv). The grazing (Pasture) land rental market equilibrium of Fig. 2b occurs at R_g° in panel ii, where the sum of supplies, $Gs+Cg$, equals the cattle-derived demand for grazing land (*Gd*).

Excess supply curves define the availability of land for energy crops in Fig. 2. Cropland use for energy occurs along the excess supply curve *Ce* in Fig. 2a (panel i).[3] In turn, excess supply of cropland is the difference between supply (*Lc*) and demand ($Cc+Cz$) at a given price in panel iii. Similarly, grazing land use for energy occurs along excess supply curve *Ge* in Fig. 2b (panel i). Hence, expanding cropland is available for energy crop production at increasing land prices (rental rates), because the energy crops must bid available land away from profitable uses in food crops and energy. Also, expanding grazing land for energy crops is available for energy crop production at increasing pasture land rental rates (prices) because the energy crop must bid available land away from profitable uses for livestock grazing, and additional pasture land supply must be attracted from unused land and low-quality cropland.

Estimated relationships of Farm Land use update previous estimations (Gallagher and Shapouri, 2008). We updated grazing land supply, CRP demand, and the use of cropland for pasture using data from the 2007 Census of Agriculture. We extended the analysis of cropland demand to include separate land rental demand relationships for the main feed and food crops: corn, soybeans, and wheat.

The main supply and demand relationships to describe a hypothetical BF industry are also included in the model. In particular, three classes of biomass inputs are included: corn stover, cropland, and pastureland. Stover cost estimates are developed from recent estimates (Gallagher and Baumes, 2012). The counties in each state are arranged from low cost to high cost, and cumulated for a state level supply curve for each state. Next, switchgrass is the reference biomass crop. Costs can vary across states due to differences in land rental rates and crop yields, according to a cost function that includes establishment cost and annual maintenance cost (Gallagher and Shapouri, 2008, p. 6). Updated establishment and maintenance cost parameters are used (Duffy, 2008a).

Switchgrass grown on pasture is based on the same cost function specification and parameters. However, we assume that switchgrass on former pastureland has a 20% yield discount from cropland (Downing and Graham, 1996).[4] Biomass costs vary from state-to-state because of unique biomass yields, cropland rental rates and pasture rental rates. Details of the biomass handling and storage cost estimates are given by Gallagher and Baumes (2012, on p. 15).

[3] Statistically, there is a connection between cropland use for energy and agricultural land values for the corn ethanol expansion under the RFS.

[4] The cattle stocking rates and grazing season length for Iowa suggest a similar yield discount for maintained pasture. Specifically, the recommended stocking rate for maintained pasture in Iowa is one cow and one calf (Duffy and Edwards, 2008b). Using a daily forage rage of 33.4 lb/day and a season length of 146 days gives a yield of 2.43 t/acre. The expected Iowa switchgrass yield is 4.0 t/acre, so the ratio of pasture yield to cropland yield is 0.61.