Producer Preferences and Characteristics in Biomass Supply Chains

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Abstract

Organizational costs in biomass transactions could be a key barrier to commercial development of cellulosic based industries. Understanding biomass producer characteristics and preferences will be important to the future development of renewable industries like cellulosic ethanol. In this paper survey data are analyzed that identify assets biomass producers currently own, services they are willing to provide and their preferences for selling mechanisms. A multinomical logit model is used to analyze producer preferences.

Introduction

There are many aspects of developing biomass industries like cellulosic ethanol that require research. Generally, energy conversion processes have yet to be developed that are cost competitive with conventional technologies. Cellulosic ethanol has yet to be produced at a commercial level. Even after technology improvement occurs industry development from an organizational stand point is not well understood. It is the latter point this paper tries to address.

Regardless of the resulting technology from technological improvement the biomass must be traded between grower and energy processor, unless these stages are integrated under unified ownership. How the biomass is traded directly affects the underlying cost competitiveness of the new technology. In a recent survey of the current biopower industry (a more mature thermal conversion industry), organizational costs make up 15 percent of total costs (Altman and Johnson, 2008). Thus in addition to traditional production costs like energy conversion and biomass feedstock costs, organizational costs will be significant.

There are several ways to examine the organization of a potential bioenergy industry like cellulosic ethanol. Current industry structure of similar industries like biopower could be examined. This approach is taken elsewhere, Altman et al. 2007a and Altman and Johnson 2008. The procurement strategies and contracting efforts of potential cellulosic ethanol processors on the cusp of commercialization could also be taken into account (Altman et al. 2007b). The other side on the transaction is the biomass producer. This paper examines the preferences and characteristics of potential biomass suppliers with the aim of understanding how future biomass to energy industries could develop. Specifically this paper answers how biomass producers prefer to structure potential biomass exchanges, what assets they currently own that could support the industry and what potential services they could be willing to supply. This evidence could be useful to industry developers trying to establish new biomass based industries.

Literature

It is beyond the scope of this paper to review the full biomass and bioenergy literature. Yet to provide some context and justify the approached taken a short literature review is undertaken. Generally the biomass and bioenergy literature is focused on more technical issues, such as the environmental effects of bioenergy and technology development issues, compared to the organization of future bioenergy industries.

There is some coverage of the organizational challenges. Klass (1998) observes that shipping and storage strategies have been counter to industry developer advice. van Loo and Koppejan (2003) observed that organizational changes like developing biomass content standards could solve technical challenges such as fouling of biopower systems. These

examples indirectly document the potential organizational challenges while focusing on traditional biomass and bioenergy topics.

More directly addressing the choice of organizational form, Overend (1993) considers potential exchange mechanisms bioenergy producers and biomass suppliers could utilize. Overall he concludes that spot markets should be developed where independent biomass producers sell there products to independent bioenergy processors. On the choice of organizational form Downing et al., (2005) recommends vertical integration and specifically biomass producer cooperatives to organize the biomass exchange. In this unified ownership structure the biomass producers would vertically integrate into the bioenergy production stage. Klass goes one step further to recommend horizontal and vertical integration. Not only should there be unified ownership along the supply chain between biomass production and bioenegy production but producers should integrate other forms of bioenergy production, for example, producing biopower from the lignin co-product from cellulosic ethanol.

Altman and Johnson (2008) found that the current biopower industry is highly vertically integrated. Approximately 75 percent of the biopower industry is vertically integrated between biomass production and biopower production stages. Thus if future bioenergy industries will be anything like biopower they could be highly vertically integrated. Altman et al. 2007b found that future cellulosic ethanol processors are considering hybrid forms of organization in the form of formal contracts. Short term and long term contracts are also alternative methods of exchange compared to spot markets and vertical integration.

Methodology

The theoretical model is generally based on Williamson (1985, 1991, and 1996). This model is unique in economics because of the focus on the choice of organizational form. The basic foundation of Williamson's transaction cost economics is to model the choice of organizational form as some function of the characteristics of the transaction. Characteristics of assets that support that transaction are identified as the key explanatory variable. The main assumption of the theory is that firms choose the least cost organizational form to conduct the transaction.

The key flow of causation in transaction cost economics is that characteristics of the assets that support the exchange cause different levels of transaction costs for potential organizational forms. Asset specificity, or the degree of redeployability of an asset, is identified as a key transaction cost variable. If an asset is easily redeployable the low cost organizational form is expected to be spot markets while if an asset is not redeployable alternative organizational forms like contracting and vertical organization are expected.

In this application to potential biomass exchanges, important assets include the various equipment necessary for biomass collection, transportation and storage. The degree of asset specificity is measured simply as the existence of the equipment in the producers current operation. Hence if the producer has already invested in the necessary equipment for hay, straw or stover harvest it is assumed to be an indication of high redeployability (low asset specificity). Such an observation is expected to be associated with a preference for spot markets or short term contracts. Otherwise if a producer does not already own the equipment and would need to purchase such equipment to take part in the new biomass industry; this

would be an indicator for high asset specificity and is expected to be associated with preferences for vertical integration or long term contracting.

In addition to asset characteristic variables producer demographic characteristics are added in an ad hoc fashion. Thus several of the explanatory variables are included in an inductive manner and do not have expected signs.

Data were collected in a mail survey conducted by the University of Missouri-Columbia Community Policy Analysis Center and the Southern Illinois University-Carbondale Department of Agribusiness Economics. The surveys were mailed out to 2500 producers based on a random sample from a list provided by the National Agricultural Statistics Services. From this population 590 responded with returned surveys and 10 responded over the phone. This is a 24% response rate. The sample of 600 includes all producers who responded to the survey, however, several respondents replied that they would not complete the survey due to a list of reasonable excuses such as retirement and death. For this reason 40 of the responses did not provide useable information and the following analysis is based on 560 responses.

After presenting summary statistics the main empirical model is based on a choice model, a multinomial logit (mlogit). In the mlogit, multiple alternatives of the dependent variable can be regressed against continuous and non-continuous explanatory variables. The dependent variable in this application is the indicated preference for the choice of organizational form by the individual producer. In this model the choice of organizational form includes four alternatives: spot market, short term contract, long term contract, or vertical integration (a producer cooperative). The choice of organizational form is regressed

against producer characteristics such as age and income level, and characteristics of the operation such as assets owned and scale (seeded acres).

In general mathematical notation the empirical model can be described as producer i facing J unordered choices. The response probability that producer i prefers alternative *j* (P_{ij}) is modeled as:

$$P_{ij} \equiv P(Yi = j|X) = \frac{\exp(\beta_j X_i)}{1 + \sum_{j=1}^{J} \exp(\beta_j X_i)} \quad (1)$$

where P_{ij} is the probability $Y_i = j$ or that producer i prefers category *j* organizational form given the explanatory variable vector *X*, β_j is the estimated parameter vector and X_i is the observed characteristic vector of producer *i*.

In specific form, there are four choices of organizational form, thus $j = 0,1,2,3$ and $i = 341$, the number of completed surveys that had usable data. The log likelihood function for this multinomial logit can be expressed as:

$$\ln L = \sum_{i=1}^{341} \sum_{j=0}^{3} d_{ij} \ln P_{ij} \quad (2)$$

where $d_{ij} = 1$ if firm *i* chooses organizational form *j*. Explanatory variables based on equipment ownership are binary variables, acreage is continuous and variables like age and income are categorical groups.

In multinomial logit models the p-values are valid, making significance tests meaningful, but the signs and magnitudes of the coefficients have no direct interpretation. The partial marginal effects for continuous variables can be calculated as:

$$\frac{\partial P_{ij}}{\partial X_k} = P_{ij}\{\beta_{jk} - [\sum_{h=1}^{J} \beta_{hk} \exp(X\beta_h)] / g(X, \beta)\} \quad (3)$$

where β_{hk} is the kth element of β_h,and

$$g(X, \beta) = 1 + \sum_{h=1}^{J} \exp(X\beta_h) \quad (4)$$

and the marginal effects of limited explanatory variables are calculated as the difference between probabilities (Wooldridge, 2002).

Multinomial probits and logits can have an econometric issue arise, called the irrelevance of independent alternatives. In mlogits and mprobits alternatives are assumed to be independent and the existent of one alternative should not influence the probability of observing other alternatives. This could be an issue in the current application if spot markets and short term contracts or short term contracts and long term contracts are found to be interrelated.

Results

The objectives of this paper were to identify the assets and services producers have or are willing to provide in order to support a bioenergy industry based on row crop waste and surplus hay while investigating their preferences on how to organize the industry. In terms of the assets and services this area was found to be well equipped since 89 percent of producers were found to have a tractor capable of operating a round baler while 61 percent have a round baler. Fewer producers at 10 percent had a square baler. The percentage of producers with baling experience was 86 percent and two thirds or 66 percent had a truck and trailer capable of hauling bales. Table 1 presents these data.

Table 1: Summary Statistics for Producer Assets

Variable	Observations	Frequency of Affirmative Response	Percent
Round baler ownership	551	340	61.71
Tractor ownership	548	493	89.96
Square baler ownership	545	59	10.83
Baling experience	545	471	86.42
Truck and trailer ownership	547	362	66.18

In terms of the services the producers were willing to provide the results were not as high. Results indicate 33 percent to 43 percent were willing to provide the various services such as providing their biomass in a windrow, baling and stacking in the field, long term storage or delivery. Table 2 presents these data.

Table 2: Summary Statistics for Services

Variable	Observations	Frequency of Affirmative Response	Percent
Windrowing	558	187	33.51
Baling	558	244	43.73
Storing	558	201	36.02
Delivering	558	212	37.99

Overall the general willingness to supply biomass was in the range of 21 to 38 percent. Producers were asked "Under the right conditions, such as price and agronomic factors, what is the maximum portion of your annual cereal straw, corn stover and hay that you could make available for market?". Table 3 summarizes these data.

Table 3: Summary Statistics for General Willingness to Supply

Variable	Observations	Mean	Std. Dev.	Min	Max
Straw	416	38.09	41.35392	0	100
Stover	400	32.52	39.8709	0	100
Hay	431	21.45	33.35961	0	100

The preferred organizational form analysis first examines the main dependent variable, the choice of organizational form. Then the data are examined with the mlogit procedure. The summary statistics on the dependent variable are present followed by the results of the mlogit.

The dependent variable for this analysis is the preference of organizational form. About 38 percent of respondents preferred spot markets, 22 percent producer cooperatives and 16 percent each for short term and long term contracts. Another 6.8 percent listed multiple top preferred organizational forms. Table 4 displays these data.

Table 4: Summary Statistics for Preferred Selling Mechanism

Variable- Question 19 Preferred Mechanism	Frequency	Percent
Spot market	155	37.99
Short term contract	69	16.91
Long term contract	66	16.18
Producer cooperative	90	22.06
Multiple top choice	28	6.86
Total	408	100

Taking into account second choices, spot markets were among the top two choices for 65 percent of producers while cooperatives were a top two choice of 52 percent of producers.

Short term contracts were chosen as a top two choice by 51 percent of producers while long term contracts were a top two choice of only 37 percent of producers.

From these rankings producers in this area prefer spot markets. Once second choices are taken into account cooperatives are followed closely by short term contracts. Long term contracts would appear to be the least preferred organizational form. From this evidence short term relationships in the form of spot markets and short term contracts could be efficient exchange mechanisms. This would also be supported by the high percentage of producers who already own baling equipment.

For regression analysis six explanatory variables were selected out of a potential 21 based on correlation coefficients and category of the variable. For example, in the category of crop acreage, cereal acreage was found to have a correlation coefficient of 0.036, corn acreage 0.032 and hay 0.029. Therefore, to avoid multicollinearity, cereal acreage was chosen from this category. The six variables selected were cereal acreage, tractor ownership, square baler ownership, whether producers currently shredded their corn stocks, willingness to supply biomass in a windrow and age.

The dependent variable for the regression analysis is the top choice of organizational form. In our sample, 341 producers identified a clear top choice while the other respondents either did not answer this question or identified multiple top choices. Of these 341 respondents, 155 or 40% chose spot markets as their top choice, 70 or 18% chose short term contracts, 66 or 17% long term contracts and 90 or 23% producer cooperatives. Table 5 presents the regression results.

Table 5: M-Logit Regression Results

Variables Dependent variable Preferred Organization	Coefficients	P-value
Short Term Contract Alternative		
Explanatory Variables:		
Age	0.013	0.958
Windrow	0.379	0.216
Corn stocks shred	0.045	0.899
Square baler ownership	0.230	0.673
Tractor ownership	0.757	0.254
Cereal acres	0.0008	0.529
Long Term Contract Alternative		
Explanatory Variables:		
Age	0.443	0.132
Windrow	0.303	0.352
Corn stocks shred	0.555	0.118
Square baler ownership	0.184	0.745
Tractor ownership	1.036	0.194
Cereal acres	0.002	**0.009**
Producer Cooperative Alternative		
Explanatory Variables:		
Age	0.347	0.183
Windrow	0.026	0.929
Corn stocks shred	0.204	0.537
Square baler ownership	0.760	**0.099**
Tractor ownership	1.468	**0.06**
Cereal acres	-0.0007	0.665
(topchoice= spot market is the base outcome)		

Table 5 shows that few explanatory variables are statistically significant in explaining the difference between spot markets and the other choices of organizational forms. Out of 18 potential variables only three were statistically significant. Statistical significance is

determined by the P-value. Variables with P-values less than 0.10 are statistically significant at the 90% confidence level.

When short term contracts are the alternative to spot markets no variables are statistically significant. One variable is statistically significant in explaining the difference between spot markets and long term contracts. The cereal acres variable has a P-value of 0.009. Two variables are found to be statistically significant when a producer cooperative is the alternative.

The multinomial logit results when producer cooperatives are the alternative choice are also reported in Table 5. Here tractor ownership and square baler ownership are statistically significant at the 90% confidence interval. The stronger statistical results when long term contracts and cooperatives are compared could be because long term contracts and cooperatives have more differences than spot markets and short term contracts.

Statistical tests however reveal that the alternatives are indeed independent. In conducting the Hausman test and Small-Hsiao test for the independence of irrelevant alternatives, both tests do not reject the null hypothesis that the assumption of the independence of irrelevant alternative holds. In two subsequent models spot markets and short term contracts are combined and short term contracts and long term contracts are combined as alternatives. Neither modeled increased the statistical significances of explanatory variables.

Conclusion

Overall this article provides some evidence that producers prefer spot markets or short term relationships over other exchange mechanisms in this area. This contradicts what

has occurred in the biopower industry where vertical integration has occurred in three quarters of that industry and early attempts to organize the cellulosic ethanol industry where technology developers such as Iogen have signed long term contracts with producers.

Econometric models do not show statistical significant patterns explaining why producers have these organizational preferences. Most variables are not statistically significant; the organizational preferences are unrelated to asset or demographic variables. Addressing econometric issues such as the independence of irrelevant alternatives did not reverse statistical significance.

Results for assets and services that producers are willing to provide should be compared to results from other areas. Overall producers in this area seemed to have assets needed to support the industry. The services required to support the industry was less certain. Researchers should also work with industry developers to develop other indicators, variables and other important biomass producer's preferences and characteristics.

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