Risk, Infrastructure and Industry Evolution

Proceedings of a conference June 24-25, 2008, in Berkeley, California

Edited by

Burton C. English
Department of Agricultural Economics
The University of Tennessee
Knoxville, TN

R. Jamey Menard
Department of Agricultural Economics
The University of Tennessee
Knoxville, TN

Kim Jensen
Department of Agricultural Economics
The University of Tennessee
Knoxville, TN

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Factors Determining Corn-Based Ethanol Plant Site Selection, 2000-2007

Lance A. Stewart and Dayton M. Lambert[1]

Introduction

As investors continue to look for optimal sites for ethanol plants, investigating the factors determining community comparative advantage with respect to attracting outside investment has flourished. A new ethanol plant may create local jobs, and increase the tax base and income through the backward and forward linkages agriculture has with the economy (Novack and Henderson, 2007). Existing ethanol plants are usually located near ample feedstock supply, reliable transportation systems, and close to adequate water and energy sources (Rose, Detch, and Morgan, 2005). But no matter the geographic location, the long-run profitability of an ethanol plant depends on minimizing production costs (Dhuyvetter, Kastens, and Boland, 2005). Low-cost production is achieved by minimizing feedstock procurement, natural gas, and labor costs. Feedstock procurement costs decrease when feedstock supply is abundant and transportation infrastructure is reliable. Ethanol producers depend on efficient transportation and coproducts handling, as well as availability of other resources required to produce biofuels (Baker and Zahniser, 2006). The natural gas used in the fermentation process is another important cost. On average, grain-based ethanol plants use 34,800 Btu of thermal energy per gallon of ethanol (Shapouri and Gallagher, 2005). Thus, proximity to natural gas pipelines and distribution centers may be an important location determinant (Shapouri and Gallagher, 2005). Additionally, to increase profitability, ethanol producers can market coproducts such as Distillers' Dried Grains with Solubles (DDGS), a relatively high protein livestock feed supplement. Therefore, locating near livestock operations may also reduce DDGS transport costs (Baker and Zahniser, 2006). Statewide and federal policies influence site selection. Most states with significant ethanol production typically have some form of ethanol subsidy, incentive, or initiative (Parcell and Westhoff, 2006). Several studies identify the geographic attributes attractive to ethanol producers with respect to siting plants (e.g. Baker and Zahniser, 2006; Dhuyvetter, Kastens, and Boland, 2005). However, research identifying the location determinants at the national level remains limited.

[1] Stewart is a Graduate Research Assistant and Lambert is an Assistant Professor, all respectively, in the Department of Agricultural Economics at the University of Tennessee, Knoxville, Tennessee.

This study examines the influence local market factors, transport and utility infrastructure, labor, state policy and demographic characteristics have on ethanol plant location decisions in the contiguous forty-eight United States for the years 2000 through 2007. Regression analysis and clustering methods measure the factors influencing the likelihood an ethanol plant locates in a given county. The procedure isolates clusters of counties more likely to attract investment. It is hypothesized that location determinant effects vary spatially; suggesting that comparative advantage with respect to attracting ethanol plant investment will vary across the urban – rural geography. Appreciating the geographic diversity of location determinants and their relationship with site selection decisions provides a model for ranking communities competing for ethanol plant investment.

Conceptual Framework, Empirical Model, and Estimation Procedures

The same factors influencing food manufacturing plant location determine ethanol plant location choices; namely market access, agglomeration economies, and infrastructure (Henderson and McNamara, 2000). Supply-oriented food processors locate near agricultural inputs to minimize procurement costs. The ethanol industry falls into the supply-oriented firm type because feedstock costs dominate ethanol production costs. Conceptually, the location decision is represented as $Z_i = g(\mathbf{M}_i, \mathbf{L}_i, \mathbf{I}_i, \mathbf{P}_i, \mathbf{F}_i)$, where Z_i is the site choice in location *i*, g(•) is a cost minimizing site-selection function, and **M**, **L**, **I**, **P**, and **F** are vectors of community attributes including input and product markets (**M**), labor attributes (**L**), infrastructure (**I**), state incentives (**P**), and local fiscal characteristics (**F**) influencing production costs respectively. Details of the variables making up the location determinants in M, L, I, P, and F are discussed below. Also, descriptive statistics of variable are included in Table 1.

Table 1. Descriptive Statistics of Location Determinants

Variable	Description	Location Determinants	Mean	Standard Deviation
ANN	Location Announcements (2000-2007)		0.020	0.140
ACTIVE	Active Ethanol Plants (2000-2007)		0.035	0.183
FARMPROP	Farm proprietor income/nonfarm proprietor income (2000)	M	0.190	0.557
CATTLE	Cattle, plus surrounding counties (1000,000s head)	M	2.007	2.045
CORN	Average total corn production plus surrounding counties (1990-2000) (100,000s bushels)	M	171.266	217.756
STORE	Farm product warehousing operations (Location Quotient) (2000)	M	2.117	13.963
NATGAS	Natural gas distribution centers (Location Quotient) (2000)	M	3.308	8.114
GAS	Gas stations, plus surrounding counties (2000)	M	6.894	3.429
ESTAB	Existing ethanol plant before 2000 (1 = yes)	M	0.010	0.106
HERFEMP	Employment concentration index, 2000 (between [0,1])	L	0.121	0.052
WAGE	Average wage per worker ($), 2000	L	12.307	2.761
HS00	% with high school diploma, 2000	L	77.321	8.732
TRUCKLQ	Trucking companies (Location Quotient), 2000	I	2.076	1.897
ROAD	Road density (road miles/county area)	I	0.457	0.272
RAIL	Rail density (rail road miles/county area)	I	0.307	0.402
RIVER	River adjacency	I	0.326	0.469
FISC	Per capita income taxes/county expenditures, 2000	F	0.337	0.229
TAX	State excise tax incentive (2001) (1 = yes)	S	0.133	0.339
PRODCR	Ethanol producer credit program (2001) (1 = yes)	S	0.233	0.423
MTBE	Methyl tertiary-butyl ether ban, 2000 (1 = yes)	S	0.185	0.388
IRR2000	Waldorf's (2006) 2000 rurality index (between [0,1])		0.501	0.177
HLAND	Heartland (1 = yes)		0.178	0.382
NOCRES	Northern Crescent (1 = yes)		0.138	0.345
FRUIT	Fruitful Rim (1 = yes)		0.091	0.288
NOGRTPL	Northern Great Plains (1 = yes)		0.058	0.235
PRGATE	Prairie Gateway (1 = yes)		0.128	0.334
BRANGE	Basin and Range (1 = yes)		0.064	0.245
MISSPORT	Mississippi Portal (1 = yes)		0.054	0.226
SOSEA	Southern Seaboard (1 = yes)		0.155	0.362

This closely follows the methodology used by Lambert *et al*. (2008) in their analysis of ethanol plant location decisions in metropolitan and nonmetropolitan counties. This research differs in that a bivariate probit regression jointly models ethanol plant location announcements and plants operating from 2000 to 2007. It is hypothesized that the location decisions of established plants influence the site selection decisions of new plants. Negative correlation between the location decisions of established and new plants may suggest competition for limited feedstock resources. That is, given an established ethanol facility, a newly proposed facility will tend to locate farther away from the established plant to access feedstock sources not consumed by the active operation.

County-level factors are regressed against variables indicating where ethanol plants became operational from 2000 to 2007 and ethanol plant location announcements between the same period (equation 1):

$$\Pr[Z_i^t = 1] = \Phi_{BVN}(RI_i, RI_i{*}\mathbf{M}_i, RI_i{*}\mathbf{L}_i, RI_i{*}\mathbf{I}_i, RI_i{*}\mathbf{F}_i, RI_i{*}\mathbf{P}_i, \mathbf{M}_i, \mathbf{L}_i, \mathbf{I}_i, \mathbf{F}_i, \mathbf{P}_i, \beta^k, \rho),$$

where Pr = probability; $t \in [ANN, EST]$; Z_i is a binary variable indicating if there was at least one active ethanol plant or ethanol plant announcement in a county between 2000 and 2007; Φ_{BVN} is the standard bivariate normal cumulative density function; $\mathbf{M}_i$, $\mathbf{L}_i$, $\mathbf{I}_i$, $\mathbf{F}_i$, and $\mathbf{P}_i$ are the location determinants in county i; and RI is a rurality index (Waldorf, 2006). When the location unobserved factors associated with decisions are not correlated, $\rho = 0$, and plant announcement and active plant location equations are estimated separately.

The RI is a function of population, population density, the percent of the population designated as rural or urban according to the U.S. Census (2000), and the distance between a county and a metropolitan statistical area (OMB, 2007). The RI is a continuous variable, bounded between [0, 1]. Counties with an RI score of 1 are remote, low population density counties (e.g., "rural"). The converse is true for counties with a RI score of 0 (e.g., "urban"). Location determinants were interacted with RI to test the hypothesis that the geographical effects of location determinants vary with respect to plant site selection, given the location of a county in the rural – urban continuum. The marginal effects of a location determinant are therefore a continuous function of the rurality index. The marginal effects of the location determinants are discussed looking at their effects in groups of counties falling into the RI categories of 0 – 0.2, 0.4 – 0.6, 0.6 – 0.8, and 0.8 – 1.0. Thus, discussion focuses on the spatial variability of the marginal costs of the location determinants in the context of this rural – urban continuum.

Data Sources

Plant location and announcement information was collected from the Renewable Fuels Association (RFA) (2008). The total number of active ethanol plants as of January 3, 2008 was 141, with 70 ethanol plant location announcements. The 2000 cutoff point was chosen for two reasons. First, all plant location announcements documented by RFA occurred during or after 2000. "Announcements" are defined as plants reporting zero production because plants were not yet constructed. Whether these plants actually begin production is not important because it is the location determinants associated with a county which initially elicited interest. Second, 78 percent (110) of the active ethanol plants began production in or after 2000, following the recent interest on expanding renewable fuel supplies in the United States.

Location determinants measured in 2000 (or prior to 2000) were used in the regression analysis to avoid potential simultaneity problems. To assess the feedstock input and coproduct output determinants on the site selection decision, crop and livestock production data for the year 2000 were collected from the National Agricultural Statistics Service (NASS) (2000) to assess the feedstock input and coproduct output determinants on the site selection decision. Demographic variables were extracted from the 2000 Census files, and information about state policy incentives was obtained from the U.S. Department of Energy (USDOE-EIA, 2001). Interstate and state highway miles, county physical attributes, navigable rivers, and per county miles of class I and II rail lines were from the GIS and mapping software ESRI (2006). Information on trucking and natural gas distribution establishments was extracted from the U.S. Census County Business Pattern files (2000). Waldorf's (2006) RI was constructed using 2000 census data and the Office of Management and Budget (OMB) urban core/non-core county classification system (OMB, 2007). There were 3,064 usable observations in the final data set after eliminating counties with incomplete information.

The goal of this study is to provide not only an economic analysis of agriculture's ability to contribute to the Congressional goal of supplying 18 billion gallons by 2016, but to also evaluate the impact the pursuit of this goal could have on this nation's environment if cellulosic ethanol is not feasible by 2016. The first objective of the study is to evaluate the ability of production agriculture to contribute 18 million gallons of corn-ethanol. The second objective is to estimate the potential environmental impacts on the nation's resources as a result of this emerging industry.

Location Determinants

Market potential of an area depends on the ability to meet demand conditional upon the supply of competing goods. Larger product markets are penetrated by exploiting lower transportation costs, which increases the competitiveness of a site. Ethanol plants locate where primary input transportation and coproduct distribution costs are minimized (Dhuvyetter, Kastens, and Boland, 2005). Net feedstock costs account for the largest share of ethanol production costs (about 55 percent of the per-unit costs) (Shapouri and Gallagher, 2005). Profit margins will decrease and coproducts marketing will become more important as the ethanol industry grows and becomes more competitive (Dhuvyetter, Kastens, and Boland, 2005). Distiller's grains (DG) may supplement livestock diets and locating near livestock operations and selling DG to livestock feed producers can potentially offset feedstock procurement costs.

Three variables measure the effects of product markets on the location decision of grain-based ethanol plants. Assuming that ethanol is primarily used as a fuel additive, the per-county number of retail gasoline businesses, and the sum of the retail gas stations in surrounding counties may account for market potential (GAS). We use retail gas businesses as a demand proxy only, based on the assumption that areas with higher concentrations of gas stations typically have higher concentrations of fuel consumers. The number of blending facilities in a county would be the ideal measure. Admittedly, the retail gas businesses only roughly approximate demand potential. The total head of cattle per county plus cattle in surrounding counties (CATTLE) measures potential access to DG markets (NASS, 2000). DG is marketed in wet and dry forms, and may need to be stored or dried before it is shipped to demand centers. Therefore, a location quotient (LQ) of farm product warehousing operations

(STORE) measures the influence storage facilities have on ethanol plant location decisions.[2]

Three variables measured the impact of access to input markets on ethanol plant site selection. Ethanol production relies heavily on the agricultural sector given feedstock demand as well as DG markets. Farm proprietor income divided by nonfarm proprietor income in a county measures the relative importance of farming on the location decision, based on the assumption that counties with relatively more income generated from farming proxy areas with a comparative advantage with respect to feedstock production (FARMPROP). It is expected that ethanol producers are more interested in the total quantity of feedstock available rather than feedstock yield. Due to the limited ability of a single county to supply all of a large ethanol producer's feedstock demand, larger operations will likely import corn from surrounding counties. The average total bushels of corn produced from years 1990-2000 in a county was added to the sum of the average total bushels of corn produced in surrounding counties to gauge access potential to corn feedstock (CORN). Strategic barriers to entry into product markets due to the presence of preexisting plants may be a factor in the location decisions (Fee, Mialon, and Williams, 2004). As more ethanol plants locate in a given county, competition for that area's resources increase. We include the number of active ethanol plants located in a county prior to 2000 as a measure of barriers to entry (ESTAB). There were at least 31 active plants producing ethanol prior to the year 2000. It is hypothesized that counties with existing active ethanol plants are less attractive to new plant investment.

Manufacturing productivity is influenced by labor quality (McNamara, Kriesel, and Deaton, 1988). Higher quality workers are typically more productive, which leads to increased productivity at a higher level of output at the same or lower costs, thereby increasing profits. It is hypothesized that a high-quality labor force will attract potential ethanol plant investment. The percent of persons over twenty-five with a high school diploma in each county (in 2000) measures labor quality effects on plant site selection (HS00).

Locations with lower labor costs have lower operating costs, increasing the attractiveness of the area (Schmenner, Huber, and Cook, 1987; Smith, Deaton, and Kelch, 1978; and McNamara, Kriesel, and Deaton, 1988). It is hypothesized that higher labor costs will be negatively correlated with ethanol plant site selection. The 2000 annual manufacturing wage per worker in each county measured labor cost effects on the location decision (WAGE).

Manufacturing productivity depends on available labor. A deep labor pool requires less recruiting and would meet the needs for a larger number of diverse firms. A diversified work force also increases the likelihood of acquiring workers with the necessary skills to fill positions at different levels of production. A Herfindahl index was used to measure the effects of a diversified workforce on the location decision of potential ethanol plant locations (Davis and Schluter, 2005). More individuals are employed by a single sector as the index approaches one.

Infrastructure consists of the physical and natural features supporting community and commercial needs by creating access to regional, national, and international markets. Ethanol production requires transportation systems to acquire inputs and to distribute ethanol and allied coproducts. Transportation networks include federal and state roads, railroads, and navigable waterways. The total county road network miles, including state highways and the federal interstate system, was divided by the county area to measure road network potential (ROAD). A similar measure was constructed for county railroad networks (RAIL). It is expected that these transportation measures will be positively correlated with ethanol plant sites. County adjacency to a river (RIVER) was used to measure the influence of river transportation opportunities on plant location decisions. Location quotients measured the influence of truck transport establishments (TRLQ). Ethanol plants use natural gas in the distillation process, which accounts for the second highest variable operating expense (Shapouri and Gallagher, 2005). Choosing sites with historically low natural gas and sufficient supplies allow ethanol firms to hedge against unavoidable fluctuations in fuel prices by keeping procurement and usage costs low. Adequate access to natural gas is also an important determinant for plant location. Location quotients were constructed to measure the influence of natural gas distribution centers (NATGAS) on site selection.

Nine states (California, Colorado, Connecticut, Iowa, Maine, Michigan, Minnesota, Nebraska, and New York) had completely banned methyl tertiary-butyl ether (MTBE) by 2001 (USDOE-EIA, 2001). MTBE was no longer used as a fuel additive in these states and ethanol became a likely substitute. The adverse environmental effects associated with MTBE induced the demand for a replacement in which the eco-friendly status of ethanol made it a prime candidate as a comparable gas-additive. By July 2001, eight states had passed an excise tax supporting ethanol producers (Alaska, Connecticut, Hawaii, Idaho, Illinois, Iowa, Minnesota, and South Dakota) (USDOE-EIA, 2001). The federal excise tax for ethanol producers was designed to make ethanol more competitive as a gasoline additive. It is hypothesized that counties in states with this policy will be more competitive (TAX). Also, by July, 2001 ten states (Kansas, Minnesota,

[2] Location quotients are a measure of specialization in a given sector. Communities highly specialized in a given sector are more likely to export that particular service or good (Shaffer, Deller, and Marcouiller, 2004).

Michigan, Montana, Nebraska, North Dakota, Oklahoma, South Dakota, Wisconsin, and Wyoming) authorized ethanol producer incentives crediting corn sold for ethanol production (PRODCR) (USDOE-EIA, 2001). This is a supply-side policy, and should have a greater effect in relatively rural, grain producing areas.

Fiscal policy includes the government expenditure patterns and tax policies of counties and states. Higher state spending can be a benefit in some instances, but states with high corporate taxes are less attractive with respect to attracting plant investment (Goetz, 1997). County-level per capita property taxes were normalized by total county expenditures per capita (in 2000) to measure fiscal policy effects on the location decision (FISC).

Regions exhibiting greater likelihood of attracting ethanol plant investment relative to other areas are identified using the selection probabilities estimated with the regressions. Spatial clustering techniques are applied using a Local Indicator of Spatial Association (LISA) to identify groups of counties forming high-probability location clusters (Anselin, 1995). A 5 percent level of significance discriminates areas that are more likely to attract ethanol plant investors.

Results and Discussion

Product markets had varying effects on an active plant siting, depending on the rurality of the county (Table 2). The relative importance of farming in a county (FARMPROP) was positively associated with active and announced plant locations. However, the effect is increasingly negative moving away from metropolitan areas. The marginal effects in Table 3 indicate that farming areas just beyond urban centers are more attractive to ethanol producers than farming areas located in the most remote counties, suggesting that farming practices in extremely rural areas may be less likely to have access to infrastructure needed for ethanol production. Likewise, the total average corn production in a county is a positive determinant for attracting both announced and active ethanol plants. But remote areas appear to have a negative association with announced and established ethanol plants location, again suggesting the importance of infrastructure that may be scarce in more remote locations. Farm storage operations are an important location determinant for established ethanol plants in rural areas, perhaps because many urban areas do not typically specialize in warehousing agricultural products. It could be argued that established ethanol plants already command available storage facilities, limiting supply for new plants. The number of cattle in more rural areas is a significant determinant for attracting ethanol plants. Due to the increasingly competitive nature of the ethanol industry, plants entering the industry may have strong incentives to locate near DG markets to lower input procurement costs. Plant announcements from 2000-2007 were negatively associated with plants active prior to 2000, suggesting that entering firms avoid locations with established ethanol plants already competing for feedstock resources. The number of retail gasoline stations outside of urban areas was positively related with ethanol plants. Conversely, announced facilities were positively correlated with retail gas stations in urban areas. Given that the number of retail gasoline stations in a given area proxies demand potential, it appears that established ethanol plants from 2000-2007 may have saturated locations near urban markets.

Wages had a negative effect on plant location announcements in urban areas. Labor quality appears to be an important consideration for plant location. Rural areas become more attractive to potential ethanol plant investors as the number of individuals with high school diplomas increases. Labor pool diversity in rural areas appears to be an important factor in plant location. The probability of a plant locating in a county decreases the less diverse the workforce is, which may correspond with a more homogenous economy.

Road density in rural areas is an important location determinant for active ethanol plants. However, road density was not correlated with proposed plant sites. New plants flooding the ethanol market at the turn of the century probably occupied prime locations first, including well developed primary and secondary road networks, which in turn may have sent new ethanol plants in search of sites with access to secondary transportation sources, such as rail lines or river access. Counties with well developed rail systems may have a comparative advantage over other counties with respect to attracting potential ethanol plant investment. Urbanized counties with access to river transportation services were positively correlated with plant location announcements, but more remote rural areas may not have the infrastructure to support such activities. The number of trucking establishments in more urban areas appears to be an important determinant. Counties with relatively more trucking facilities may be able to support the transportation demand of ethanol plants. Access to natural gas distribution centers did not appear to be a factor with respect to plant location announcements in either urban or rural counties.

State excise taxes were positively correlated with ethanol plant announcements. In addition, producer credit incentives were a positive location determinant for established ethanol plants in rural areas. The ban on MTBE was not a significant factor with respect to plant location announcements but it was positively correlated with active ethanol plant sites in more urban areas. Per-capita property taxes became an increasingly negative factor in rural areas with respect to attracting ethanol plants.

The spatial distribution of the estimated site selection probabilities for grain ethanol plant announcements and ac-

Table 2. Bivariate Probit Estimates, 2000-2007

	Announced		Active	
Variable	Estimate	T test[a]	Estimate	T test
CONSTANT	1.379	0.776	1.499	0.929
FARMPROP	2.408	3.459	2.472	3.875
CATTLE	-0.045	-0.729	0.151	2.647
CORN	0.002	3.056	0.002	4.412
STORE	-0.009	-0.977	-0.044	-1.960
NATGAS	0.036	1.901	0.003	0.114
GAS	-0.104	-2.233	0.120	2.810
ESTAB	-7.376	-3.604	0.492	0.666
HERFEMP	8.078	2.975	-0.287	-0.097
WAGE	-0.163	-3.133	0.022	0.648
HS00	-0.021	-1.083	-0.056	-3.010
TRUCKLQ	0.424	3.101	0.303	2.452
ROAD	-0.675	-1.158	-0.766	-1.531
RAIL	-0.870	-2.015	-0.471	-1.307
RIVER	0.831	3.770	-0.155	-0.741
FISC	-1.442	-2.166	0.991	1.705
TAX	-0.282	-0.811	0.122	0.432
PRODCR	-0.049	-0.154	-0.342	-1.229
MTBE	-0.007	-0.024	1.110	4.623
RI2000	-13.457	-3.991	-12.254	-4.020
RI FARMPROP	-3.091	-3.301	-3.044	-3.546
RI CATTLE	0.218	1.976	-0.135	-1.324
RI CORN	-0.004	-3.649	-0.003	-3.261
RI STORE	0.021	1.148	0.070	1.952
RI NATGAS	-0.036	-1.329	-0.028	-0.672
RI GAS	0.132	2.079	-0.118	-2.025
RI ESTAB	1.220	0.312	-1.709	-1.096
RI HERFEMP	-11.452	-2.451	-10.589	-1.927
RI WAGE	0.251	2.550	-0.093	-1.224
RI HS00	0.118	3.088	0.165	4.587
RI TRUCKLQ	-0.534	-2.489	-0.363	-1.961
RI ROAD	0.284	0.206	2.332	1.987
RI RAIL	4.988	4.456	2.221	2.284
RI RIVER	-1.781	-3.771	-0.088	-0.211
RI FISC	1.317	1.087	-2.810	-2.516
RI TAX	1.375	2.202	0.514	1.025
RI PRODCR	0.065	0.110	1.549	2.955
RI MTBE	0.737	1.446	-1.113	-2.480
N	3064			
Log likelihood	-584.152			
ρ	-0.988			
Psuedo R^2	0.229			

[a] T tests of 1.645, 1.961, and 2.577 are significant at the 10%, 5%, and 1% levels respectively.

Table 3. Marginal Effects[a]

Plant Announcements	Rurality Index				
Variable	0.0 - 0.2	0.2 - 0.4	0.4 - 0.6	0.6 - 0.8	0.8 - 1.0
GAS	-0.000291	-0.001872	-0.000680	-0.000044	0.000044
FARMPROP	0.006735	0.043122	0.015460	0.000924	-0.001105
HS00	-0.000030	0.000412	0.000675	0.000232	0.000250
HERF00	0.022244	0.135197	0.042161	0.000233	-0.006582
RAIL	-0.001190	0.018250	0.029116	0.009924	0.010690
TRUCK	0.001188	0.007676	0.002811	0.000189	-0.000168
RIVER	0.006130	0.012140	-0.000995	-0.000874	-0.000820
CATTLE	-0.000075	0.000589	0.001143	0.000406	0.000446
CORN	0.000004	0.000011	-0.000007	-0.000005	-0.000006
TAX	-0.000373	0.004407	0.012129	0.007710	0.013862

Active Plants	Rurality Index				
Variable	0.0 - 0.2	0.2 - 0.4	0.4 - 0.6	0.6 - 0.8	0.8 - 1.0
GAS	0.001027	0.001994	0.001082	0.000195	0.000443
FARMPROP	0.020623	0.036848	0.016915	0.001786	-0.008689
HS00	-0.000377	-0.000154	0.000473	0.000312	0.003017
HERF00	-0.012808	-0.081871	-0.099345	-0.040246	-0.319396
STORE	-0.000353	-0.000547	-0.000164	0.000025	0.000608
ROAD	-0.005071	-0.001575	0.007114	0.004527	0.043349
RAIL	-0.002365	0.004622	0.011387	0.005666	0.049718
TRUCK	0.002537	0.004587	0.002162	0.000255	-0.000774
TXEXC	0.006752	0.003491	-0.007374	-0.005103	-0.050047
CORN	0.000016	0.000025	0.000008	-0.000001	-0.000022
PRODCR	-0.001388	0.003350	0.013306	0.012205	0.012079
MTBE	0.038224	0.045907	0.019838	0.002861	0.003977

[a]The marginal effects of a location determinant are a continuous function of the rurality index. For the unconditional marginal effects of a continuous factor, see Greene, 1993

tive plants are presented in Figures 1 and 2. The differences between the two spatial distributions are worth noting. The estimated site selection probability clusters (in black) for active ethanol plants are fairly concentrated in the Corn Belt. The spatial distribution of the estimated site selection probability clusters suggests that some counties in Iowa, Southern Minnesota, Eastern and Western Nebraska, Southwestern and Southeastern South Dakota, the Northern half of Illinois, a small region of California, the Texas panhandle region, Northern Oklahoma, and the mid-region of Kansas exhibit qualities attractive for established ethanol plants. On the other hand, the spatial distribution of the estimated location probability clusters of ethanol plant announcements (also in black) appears to be more dispersed. Areas in Idaho, Southern Texas, Southern California, Arizona, Wyoming, Ohio, and Pennsylvania appear to be attracting new ethanol plant investment. Also, areas with low probabilities of attracting ethanol plants are less common in the plant announcement location probability clusters, suggesting that as profits continue to become realized and the ethanol industry becomes progressively saturated, prime locations will be occupied leaving plants entering the industry searching for second-best location alternatives.

Conclusions

This analysis used regression and spatial clustering techniques to isolate which location determinants were important with respect to attracting ethanol plant investment from the years 2000 to 2007. Many of the factors hypothesized to be important were statistically significant. The relevance of location determinants varied depending on the rurality of a county, and whether the plant was active or just entering the industry. Some rural areas exhibited comparative advantage with respect to attracting ethanol investment but it appears that the most rural communities may deter potential investment. The main drivers behind the decision to locate an ethanol plant are access to feedstock and the absence of previously established ethanol plants. In addition, access to coproduct markets and transport infrastructure is also important. Some

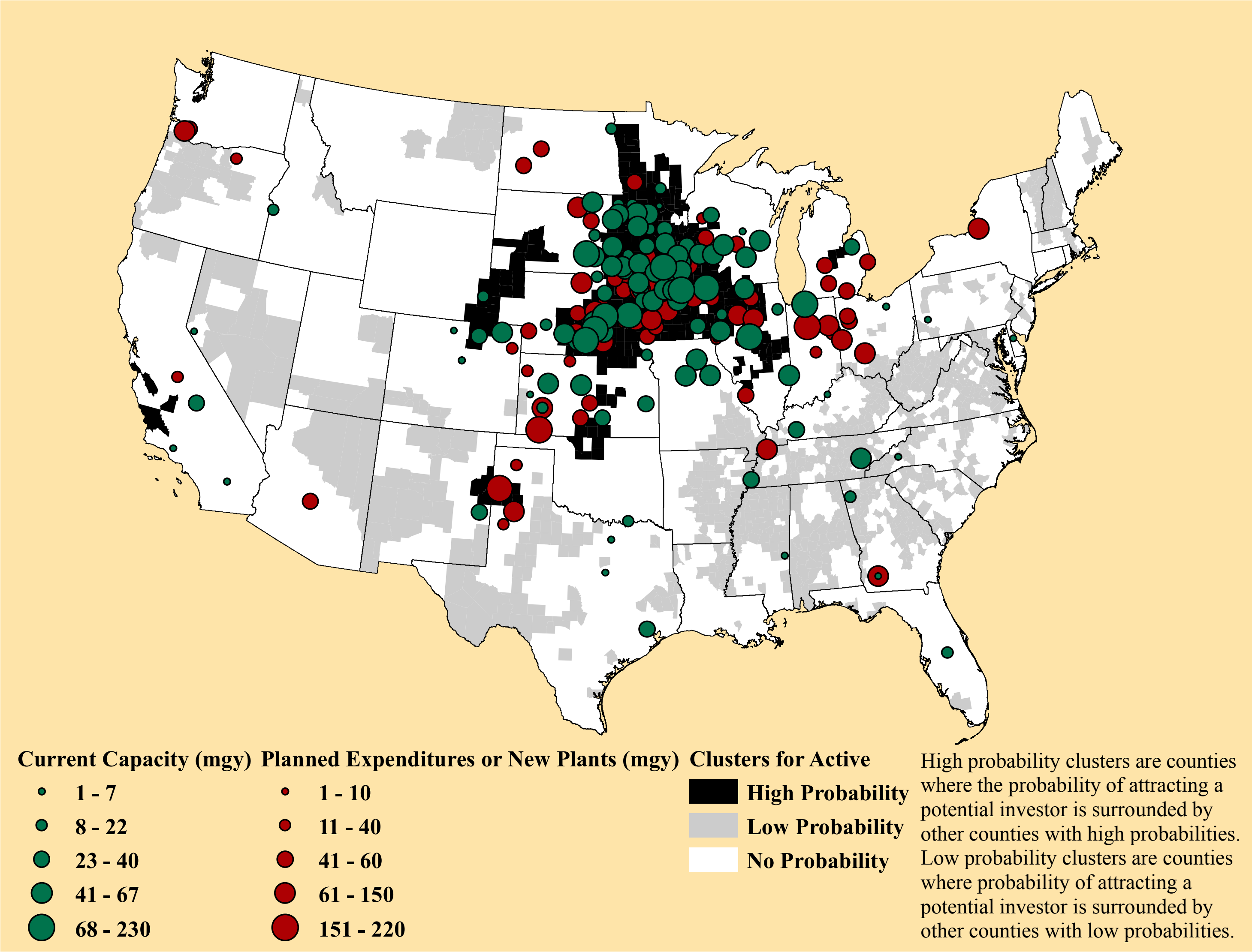

Figure 1. Established Plant Location Probability Clusters

infrastructure variables in rural areas, such as farm product storage operations and road density, were important determinants for established plants, but were not important for new plant announcements. This may be due to established ethanol plants occupying prime locations first, thereby leaving new plants to select more marginal sites. Local fiscal policy and state incentives influenced the location decisions of potential ethanol investors. There appears to be potential with respect to recruiting ethanol plant investment in some rural areas, but extremely remote areas may lack comparative advantage with respect to physical infrastructure and transportation capability.

These findings are a first-step towards understanding the interaction between ethanol plant location and local factors that provide comparative advantage to counties considering ethanol plant recruitment as a development strategy. The results are encouraging for some rural areas, but access to and the ability to provide desirable location determinants should be kept in perspective. Ethanol production is not a new technology, but the recent flurry of activity in the ethanol market indicates the industry is still in its infancy. As profit margins and access to prime locations wane, fewer firms will enter the market. As the controversy over rising fuel costs continues and demand for food and fuel from corn is pushed to the limit, the role of cellulosic feedstock will become increasingly important. Future studies analyzing location determinants will prove interesting as alternative feedstocks emerge in the ethanol industry.

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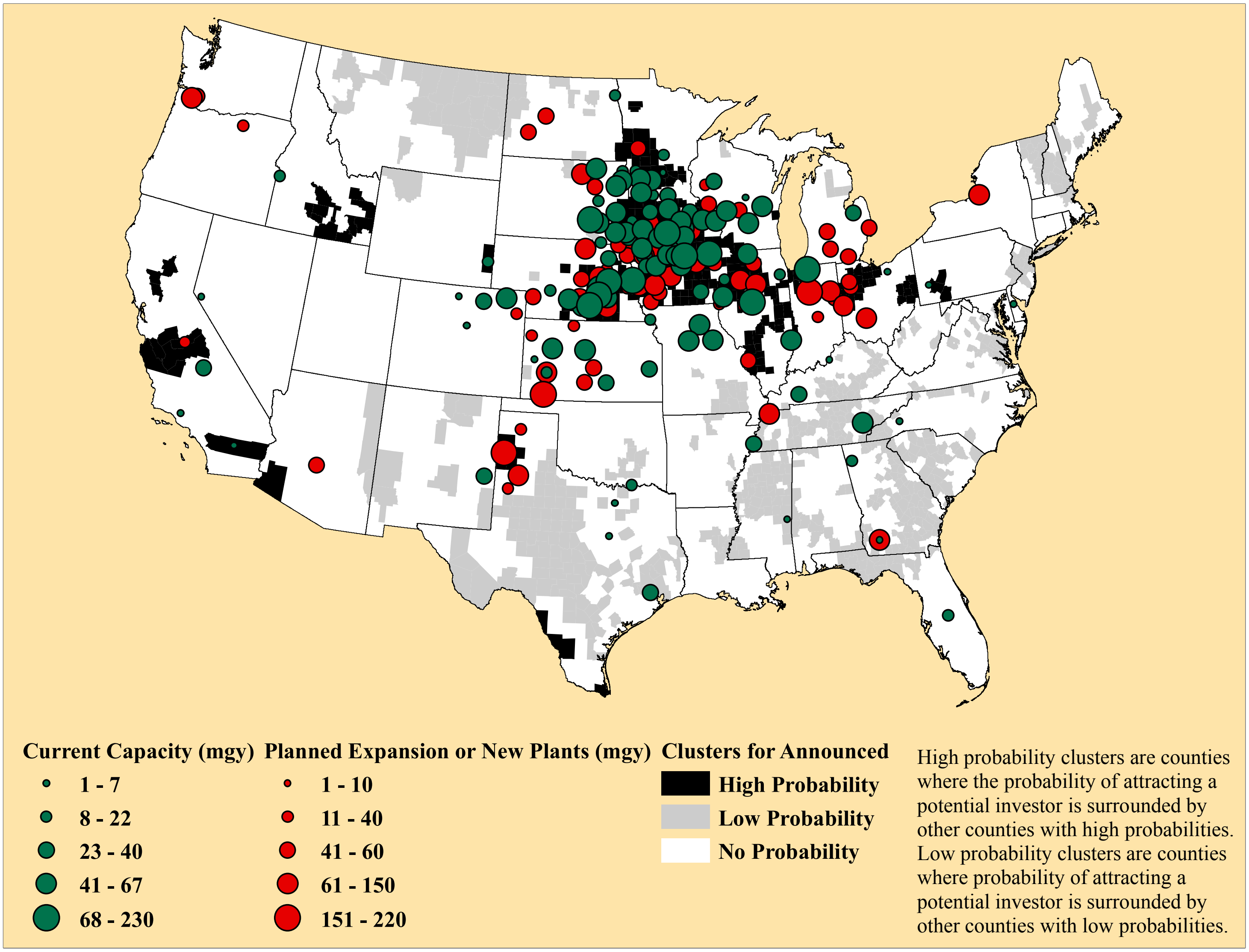

Figure 2. Announced Plant Location Probability Clusters

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