Journal of Agricultural and Applied Economics, 40,1(April 2008):117–135

Ethanol Plant Location Determinants and County Comparative Advantage

D.M. Lambert, M. Wilcox, A. English, and L. Stewart

The location of ethanol plants is determined by infrastructure, product and input markets, fiscal attributes of local communities, and state and federal incentives. This empirical analysis uses probit regression along with spatial clustering methods to analyze investment activity of ethanol plants at the county level for the lower U.S. 48 states from 2000 to 2007. The availability of feedstock dominates the site selection decision. Other factors, such as access to navigable rivers or railroads, product markets, producer credit and excise tax exemptions, and methyl tertiary-butyl ether bans provided some counties with a comparative advantage in attracting ethanol plants.

Key Words: cluster analysis, comparative advantage, ethanol production, location model

JEL Classifications: R1, R3

Ethanol production grew 20% annually between 2001 and 2006, increasing more than 455 million gallons per year (mgal/yr) (Kenkel and Holcomb). In 2006, 20% of the 12,725 million bushels of U.S. corn was used to produce ethanol (USDA 2007). By 2012, it is expected that one third of the corn crop will be used to produce ethanol (Doering). As demand for feedstock increases due to new plant locations and expansion of existing facilities, producers will enjoy higher grain prices. New plants and plant expansions will create new jobs, broaden the tax base of communities, and increase local income (Novack and Henderson). A 50 mgal/yr ethanol plant employs between 35 and 40 individuals (Swenson and Eathington), while a 90 mgal/yr plant may provide 135 full-time jobs (Shapouri and Gallagher). De La Torre Ugarte et al. estimated that 302,000 new jobs will be created by the ethanol industry, given an industry-wide 10 million gallon target by 2010. English et al. (2006) forecasted that the impact of feedstock conversion to ethanol will exceed $700 billion USD and create 5.1 million jobs by 2025.

The movement of manufacturing from core urban areas to low-cost labor sites stimulated rural industrialization in the early 1970s. Since the late 1990s, rural areas have struggled as manufacturing investment has returned to urban areas because they provide access to skilled labor, business services, and product and input markets. The promise of biofuels as an alternative energy source has rekindled the notion that rural areas may have a comparative advantage due to their access advantage to feedstock materials (Althoff, Ehmke, and Gray; English et al. 2006, 2007; Ethanol Across America; Novack and Henderson). The attraction of ethanol producers is consid-

D.M. Lambert and M. Wilcox are assistant professors, and A. English and L. Stewart are graduate research assistants, Department of Agricultural Economics, University of Tennessee, Knoxville, TN.

The authors would like to thank Delton Gerloff, professor, University of Tennessee, and three anonymous reviewers for their thoughtful comments and suggestions. The views expressed do not necessarily represent the University of Tennessee.

ered by many to be a potential mechanism to offset rural outmigration and unemployment because they provide sources of off-farm work and could increase farm income through backward linkages to local agricultural production (De La Torre Ugarte et al.; English, Menard, and De La Torre Ugarte; Evans; Parcell and Westhoff; Urbanchuk and Kapell).

Despite the potential economic gains from attracting ethanol producers, a community must have a comparative advantage with respect to its neighbors before allocating limited resources to recruit potential ethanol plant investors. The ethanol industry is commodity based, and low-cost producers will be most competitive in the long-run (Dhuyvetter, Kastens, and Boland). Communities positioned to provide investors transport infrastructure, logistical support, access to input and product markets, a low-cost and trainable workforce, and tax credits or producer incentives may have a comparative advantage when ethanol plant recruitment is included in economic development portfolios.

This article examines the influence of local fiscal attributes, market factors, infrastructure, labor, and state policy on ethanol plant location decisions in the United States between 2000 and 2007 using probit regression and spatial clustering methods. Attention is given to ethanol produced using corn as feedstock. Which communities have a comparative advantage with respect to attracting ethanol plant investment? To answer this question, a model was developed to (1) measure the factors that influence the likelihood of an ethanol facility being located in a given county, and (2) to isolate clusters of counties more likely to attract investment from the rapidly expanding ethanol industry. If the counties more likely to attract investment can be identified and the community attributes that drive site-selection decisions of investors can be compared, we might provide insight as to where local communities could focus limited resources if recruitment of ethanol production facilities is pursued as a development strategy.

The next section highlights the conceptual model used to analyze ethanol plant site selection. Location determinants and site-location measures are discussed in the second section. The third section describes the empirical model, estimation, and spatial clustering methods used to identify counties with comparative advantage with respect to attracting ethanol plant investment. Clusters were determined using estimated site-selection probabilities. The regression analysis allows for different location factor responses in metropolitan and nonmetropolitan counties. A discussion of the results follows and presents implications for rural economic development.

Conceptual Background

Manufacturing location choices are influenced by access to product and input markets, business services, and industry agglomeration. Given the numerous similarities between food production and grain-based ethanol production, previous food manufacturing location studies provide some guidance as to the factors that drive ethanol plant-location decisions. In general, food manufacturing location studies find that proximity to input and product markets, infrastructure, and labor characteristics are key location determinants (Leistritz; Lopez and Henderson; Vesecky and Lins). Goetz; Henderson and McNamara 2000; and Lambert, McNamara, and Garrett examined food-processor site selection. They concluded that the distribution of food manufacturers was influenced by the same factors that drive manufacturing plant investment decisions: access to product and input markets, agglomeration economies, and infrastructure.

Ultimately, food processors select sites based on their cost structure (Connor and Schiek). The ethanol industry falls into the supply-oriented category because its cost structure is dominated by feedstock procurement (Shapouri and Gallagher). The total cost structure of supply-oriented firms is dominated by the purchase of a single input. Supply-oriented firms are located near inputs to minimize procurement costs (Henderson and McNamara 2000). Given fixed conversion rates of biomass to alcohol, the ethanol industry can be aptly described as and industry that uses Leontief technology with respect to transformation of raw materials. However, due to variable costs incurred during the sterilization process required before fermentation, uncertainty about feedstock prices, and potential coproduct markets (e.g., distiller's grain [DG], carbon dioxide, or cellulose nanofibers; Leistritz et al. 2007), other factors also drive the location calculus of ethanol plant investors. These factors include access to natural gas, water, and electricity, penetration into livestock feed markets, and local fiscal policy or state incentives (Kenkel and Holcomb).

Firm-location decisions have been analyzed as two-stage decisions (Bartik 1985; Davis and Schluter; Henderson and McNamara 1997; Kriesel and McNamara; Lambert, McNamara, and Garrett; Schmenner, Huber, and Cook; Woodward). Investors are hypothesized to evaluate potential sites based on regional, state, and local attributes. In the first stage, a firm is hypothesized to select a region based on broad company objectives, including product market penetration, access to raw materials, increasing market share, or other criteria in the firms' objective function. In the second stage, a firm seeks a minimum cost site in the selected region for their investment. The second stage of 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, $g(f)$ is a cost-minimizing site-selection function, and **M**, **L**, **I**, **P**, and **F** are vectors of community attributes representing input and product markets, labor attributes, infrastructure, state incentives, and local fiscal characteristics influencing production costs, respectively. The first- and second-stage decisions are hypothesized to be independent.

Firms selecting an ethanol plant site are hypothesized to evaluate potential sites based on these attributes subject to an indirect cost function consistent with Leontief production technology, plus an additional cost-reducing term accounting for l potential coproduct markets: $C_m^i = q_m^i\left(\sum_k w_k^i/\alpha_k - \sum_l \theta^l p_{(i,j)}^l\right)$, where C_m^i is the cost of ethanol production in location i incurred by firm m; $q_m{}^i$ is firm m's production capacity in location i; w_k^i is the cost of the kth input at location i (including feedstock transport costs); α and θ are fixed technical coefficients converting inputs to ethanol and l coproducts (i.e., CO_2, distiller's grain), respectively; and $P_{(ij)}^l$ is the market price for coproduct l discounted for transport costs from county i to market j. Given plant m's output capacity, the optimal level of the kth input is $\bar{x}_k = q_m^i/\alpha_k$, regardless of location. In many circumstances, a given location may not be able to provide the input levels needed to produce output targets of relatively large producers (i.e., 100 mgal/yr). For example, the 99th percentile of total corn produced (in 2000) by counties was just over 29 million bushels (bu.), whereas the 75th was 6.67 million bu. A typical 100 mgal/yr corn-ethanol plant requires at least 37 million bu. of corn annually. Therefore, feedstock will most likely be imported to plants from other feedstock-producing locations. In sites where optimal input levels cannot be obtained, some amount must be transported to the production facility from another location j: $x_k{}^* = \bar{x}_k + \Sigma_j\bar{x}_{jk}$, where $\bar{x}_{jk} = 0$ when input levels at location i are consistent with planned production capacity.

Plant location in county i depends on the difference between the expected cost of locating and operating in that county, $C_m^i(q_m^i, \mathbf{w}_i) = \mathbf{w}'_i\mathbf{x}^* - q_m^i \sum_l \theta^l p_{(i,j)}^l + E[\delta_i]$, compared to expected costs in county j, $C_m^j(q_m^j, \mathbf{w}_j) = \mathbf{w}'_j\mathbf{x}^* - q_m^j \sum_l \theta^l p_{(j,i)}^l + E[\delta_j]$, where $E[\delta]$ is the expectation of a random disturbance term associated with uncertainty about input availability, product and input transport costs, infrastructure reliability, labor quality, product market potential, and other site-specific or regional attributes influencing costs that are not perfectly ascertained. When a firm has complete information about factor costs at a location relative to other locations, $\mathbf{x}^*$ is exactly determined, and $\delta = 0$.

A firm locates in a given county when expected costs are lower compared to other counties. The reduced form of the location decision defines an unobservable latent choice variable (Z^*) after combining the expected cost equations:

$$\text{(1a)}\quad \begin{aligned} Z_i^* &= C_m^j\left(q_m^j,\mathbf{w}_j\right) - C_m^i\left(q_m^i,\mathbf{w}_i\right) \\ &= \mathbf{x}_i'^*(\mathbf{w}_j - \mathbf{w}_i) + E\left[\delta_j - \delta_i\right] = \mathbf{x}_i'\beta + \varepsilon_i, \end{aligned}$$

$$\text{(1b)}\quad Z_i = 1 \text{ if } Z_i^* > 0; Z_i = 0 \text{ if } Z_i^* < 0,$$

where Z_i* is the marginal cost savings of locating in county i, and $\theta(p^l_{(i,j)}q^i_m - p^l_{(j,i)}q^j_m) = 0$ because $q^i_m = q^j_m$ and $p^l_{(i,j)} = p^l_{(j,i)}$, assuming arbitrage. Given Equation (1a,b), the location probability associated with any given county is $\Pr[Z_i = 1] = \Pr[\varepsilon_i > -\mathbf{x}_i'\boldsymbol{\beta}] = 1 - F(-\mathbf{x}_i'\boldsymbol{\beta})$, where F is a cumulative probability distribution function.

In practice, the distribution of costs expected by investors and the marginal benefit of selecting location i over other sites are not completely observed by the researcher, but the locations of active and proposed ethanol plants and site-specific location determinants are observable. A common strategy used to model this decision structure is to specify F as the cumulative density function of the standard normal or logistic distribution. In this analysis, a probit regression is used to model location probabilities associated with a given county.

Data Sources

We relied on a variety of publicly available data sources to measure the relationships among location determinants, active ethanol plants, and new ethanol plant location announcements between 2000 and 2007. The plant location information was collected from the Renewable Fuels Association (RFA) website (www.ethanolfra.org, accessed February 9, 2007). The total number of active ethanol plants (as of February 9, 2007) was 116, and there were 96 ethanol plant location announcements (Figure 1). The 2000 cutoff point was chosen for two reasons. First, all plant location announcements documented by RFA occurred during or after 2000. These included plants reporting zero production because the announcements were recent or physical construction was pending. Second, 72% (84) of the active ethanol plants began production in or after 2000.

We used two empirical models. For both models, a binary variable indicating whether a county had one (or more) active plants or new plant announcements was constructed to identify counties that had attracted ethanol plant investment. The first model correlated location determinants with site-selection announcements. Initiation of actual production did not concern us since it is the local factors associated with the county that attracted interest in the first place that are the focus here. The second model correlated local factors, while holding other factors constant, with the location of active plants. Based on the RFA information, there were 72 counties with at least one active ethanol plant before 2000. From 2000 to 2006, there were 80 counties that had received at least one location announcement from potential investors. Seven counties had at least one active ethanol plant and had received at least one location announcement during 2000–2007.

To avoid potential simultaneity problems, location determinants measured in 2000 (or prior to 2000) were used in the regressions. Crop and livestock production data for 2000 were collected from the National Agricultural Statistics Service (NASS, www.nass.usda.gov/index.asp). Demographic and economic variables were extracted from the 2000 United States Census (www.census.gov) and the Regional Economic Information System files (REIS, www.bea.gov/bea/regional/reis) compiled by the Bureau of Economic Analysis (BEA). Information about state policy incentives and local fiscal policy was obtained from the U.S. Department of Energy (www.eia.doe.gov/oiaf/ethanol3.html) and the U.S. Department of Commerce, Bureau of Census (www.census.gov/govs/www/index.html), respectively. Information about intercounty distances, interstate and state highway miles, county physical attributes, access to navigable rivers, and per county miles of class I and II rail lines was obtained from Environmental Systems Research Institute (2007). Information on trucking and local utility infrastructure was found in the 2000 U.S. Census County Business Pattern files (www.census.gov/epcd/cbp). The Office of Manage-

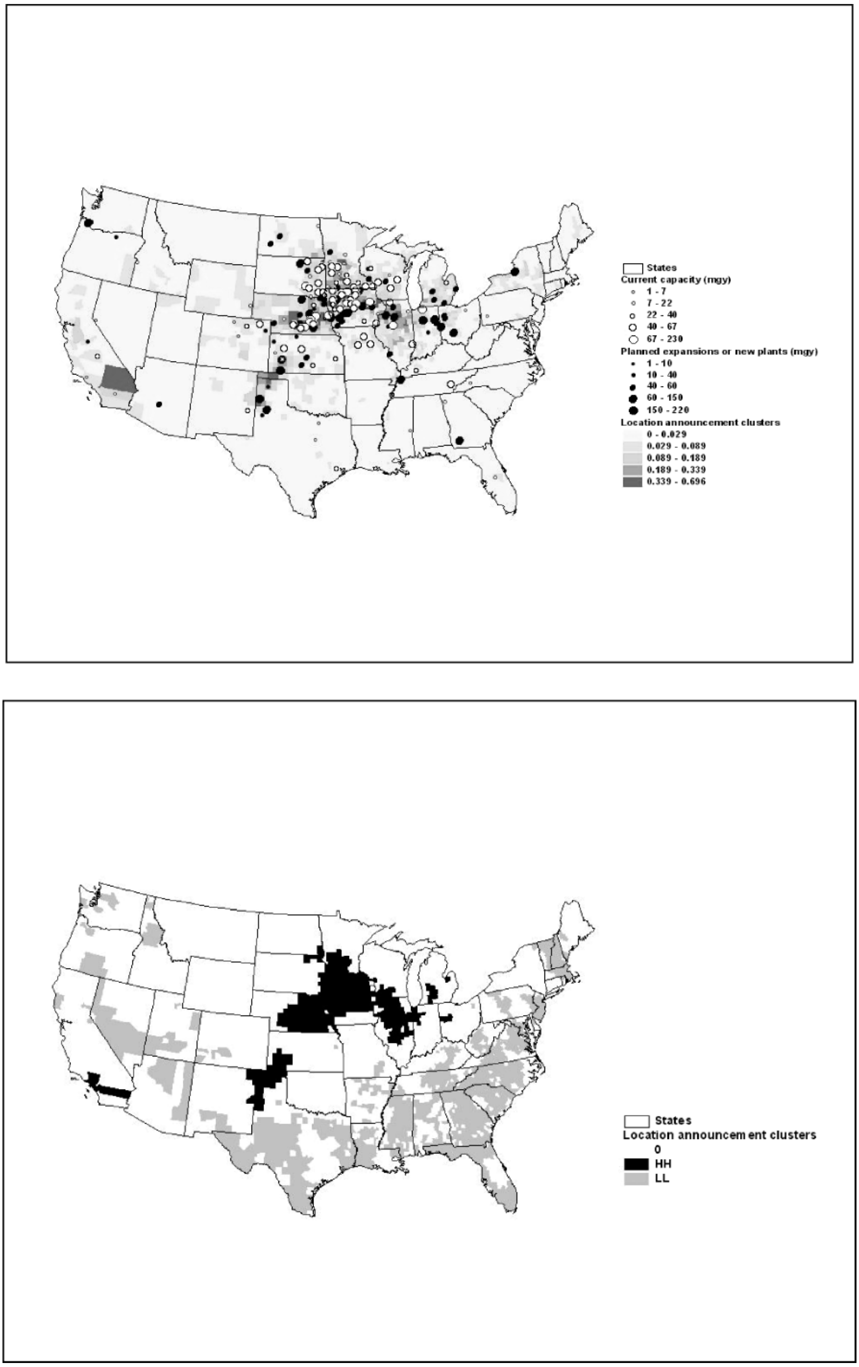

Figure 1. Spatial Distribution of Estimated Location Announcement Probabilities, Active Ethanol Plants, and Planned Plant Expansions or New Plants (Top Panel), and Plant Location Probability Clusters (Bottom Panel)

Note: High-Probability (HH) Clusters are Counties that Have a High Probability of Attracting a Potential Investor Surrounded by Other Counties with High Probabilities, etc. Areas in White Are Not Significant at the 95% Level

Sources: Top Panel, Authors' Estimates and RFA; Bottom Panel, Authors' Estimates ment and Budgeting (OMB, www.whitehouse.gov/omb/bulletins/fy2006/b0601_rev_2.pdf) classification of metropolitan and nonmetropolitan counties was used to differentiate counties into metropolitan and nonmetropolitan categories. Agricultural regions were identified according to the Economic Research Service (USDA ERS 2000) agricultural resource regions. There were 3,064 usable observations in the final data set after eliminating counties with incomplete information. Details about these variables, the empirical model, and estimation follow.

Empirical Model and Estimation

The following empirical model was used to correlate location determinants with active ethanol plants and new plant announcements:

$$
\begin{aligned}
\Pr[Z_i = 1] = {} & \Phi(NONMETRO_i, NONMETRO_i \\
& * \mathbf{M}_i, NONMETRO_i * \mathbf{L}_i, \\
& NONMETRO_i * \mathbf{I}_i, \\
& NONMETRO_i * \mathbf{F}_i, \\
& NONMETRO_i * \mathbf{P}_i, \\
& METRO_i, METRO_i * \mathbf{M}_i, \\
& METRO_i * \mathbf{L}_i, METRO_i * \mathbf{I}_i, \\
& METRO_i * \mathbf{F}_i, METRO_i * \mathbf{P}_i, \\
& \text{Regional fixed effects}) + \varepsilon_i, \\
& \varepsilon_i \sim N(0,1),
\end{aligned}
\tag{2}
$$

where Z_i indicates one (or more) ethanol plants (or announced plans to locate one) in a given county, Φ is the standard normal cumulative density function, $\mathbf{M}_i$, $\mathbf{L}_i$, $\mathbf{I}_i$, $\mathbf{P}_i$, and $\mathbf{F}_i$ are location determinants, *NONMETRO* (*METRO*) is a dummy variable identifying nonmetropolitan (metropolitan) counties, and Regional fixed effects are variables identifying agricultural production zones, soil variability, and climatic heterogeneity.

In some counties, there were multiple location announcements or active ethanol plants. Therefore, the frequency of active plants (or location announcements) observed in a given county was used to weight observations during maximum likelihood estimation. Wald statistics test the equality of metropolitan and nonmetropolitan slope and intercept coefficients. Inference is based on a bias-corrected robust covariance matrix (Davidson and MacKinnon). Given the potential for spatial error dependence, a modified Moran's *I* was used to test for spatial error autocorrelation (Kelejian and Prucha; Munroe, Southworth, and Tucker). The spatial weighting matrix used in the tests was a row-standardized, first-order contiguity matrix. Counties forming high-probability location clusters were estimated using local Moran's *I* statistics (Anselin) to determine if the pattern of predicted location probabilities formed broader, interconnected regions that exhibited greater likelihood of attracting ethanol plant investment relative to other regions. Details of the variables making up the location determinants in **M**, **I**, **L**, **F**, and **P** follow.

Product and Input Market Determinants (M)

Ethanol plants locate in sites where transportation costs for primary inputs (e.g., corn, sorghum, and other lignocellulosic materials as feedstock, natural gas to sterilize mash, and electricity for daily operations) and distribution of coproducts to markets are minimized (Dhuyvetter, Kastens, and Boland; English et al. 2006). Nearly 55% of the per unit costs of ethanol production is attributable to feedstock acquisition (including a $0.25 per gallon credit for distiller's grains) (Shapouri and Gallagher). Distiller's grains (DG) can be a valuable supplement to livestock feed, and ethanol producers can potentially offset some feedstock procurement costs related to corn or other grains by locating near livestock operations. For every bushel of corn used to produce ethanol, about 17 pounds of distiller's grain is produced (Baker and Zahniser). The ability to target DG markets is critical as the ethanol industry grows and becomes more competitive and profit margins decrease (Dhuyvetter, Kastens, and Boland).

Variable cash operating expenses of ethanol producers are dominated by natural gas and electricity costs (Shapouri and Gallagher). Fluctuations in fossil-fuel prices are beyond managerial control, but the choice of locating a site near electrical or natural gas distribution centers and other utilities is not. Well-managed firms hedge against such fluctuations to control their exposure to price volatility by choosing sites with historically lower prices and sufficient and proximate supply that keeps procurement and usage costs low.

Five variables were used to measure the effects of product markets on the location decision of ethanol investors. Per capita income in 2000 (*PCI*) was used to measure the relative purchasing power of a county's residents. Holding other factors constant, it is expected that investment decisions will orient toward counties with more purchasing power (Coughlin, Terza, and Arromdee). Assuming that ethanol is primarily used as a fuel additive, a more specific proxy of market potential and demand access could be the per county number of retail gasoline businesses plus the sum of the retail gas stations in surrounding counties. The more gas stations located in and surrounding a county, the better the chance is of greater demand potential. The 2000 number of gasoline stations per county plus the number of retail gas stations in surrounding counties was used to measure these effects (*GAS*) (expected sign is positive). The distance in road miles to the nearest metropolitan county (*DISTMET*) was used to control for the effects of transport costs and access to larger product markets in metropolitan counties (expected sign is negative). To measure access potential to the livestock feed market, the total head of all fed cattle in counties surrounding a given county was added to the per county count (*CATTLE*). Distiller's grain can be marketed in wet or dry forms. Both products may need to be stored or dried before transport to demand centers. A location quotient (*LQ*) was used to measure the effect of farm-product warehousing and storage businesses on the site-selection decision. Location quotients are a measure of specialization in a given sector, and communities highly specialized in a given sector are more likely to export that particular service or good (Shaffer, Deller, and Marcouiller).

Two variables were used to measure the impact of access to input markets on ethanol plant location decisions. It is hypothesized that ethanol producers are more interested in the total number of feedstock bushels available than feedstock yield. Given the fixed conversion factor of corn-to-ethanol and the feedstock production potential of most corn-growing counties, ethanol producers will likely have to import corn from surrounding counties by rail, truck, or barge. A single county may not be able to annually supply 37+ million bushels of corn for a 100 mgal/yr ethanol plant. Therefore, counties with good road networks and a reliable transport system to neighboring corn producing counties may have comparative advantage. The total corn production in 2000 (bushels) of a county was added to the sum of the total corn produced in neighboring counties to measure access to corn as feedstock (*CORN*, expected sign is positive).

Structural and strategic barriers to entry into input or product markets due to incumbent firms may be an important factor in the location decision (McAfee). For example, in the spirit of Bain (1956), one might consider that as economies of scale intensify with the debut of larger and more efficient plants, competition for feedstock resources increases. The earliest record of an active ethanol plant in the RFA data set is 1944. Between 1971 and 1999, an additional 26 plants started producing ethanol in the Heartland and Great Plains region. We included the number of ethanol plants located in a county prior to 2000 as a measure of barriers to entry (*ESTAB*, expected sign is negative). It is hypothesized that counties with existing active ethanol plants will be less attractive as potential sites for new entrants.

Labor Quality and Availability (L)

Manufacturing productivity is influenced by labor quality (McNamara, Kriesel, and Deaton). Higher-quality workers are generally more productive, and increased productivity leads to higher output at the same or lower costs, thereby increasing profits. In lieu of increasing demand for a wide array of labor skill sets, it is hypothesized that high-quality labor will be positively associated with ethanol plant location and site selection. The 2000 percent of individuals over the age of twenty-

Table 1. Descriptive Statistics of Location Determinants (Standard Errors in Parentheses)

Variable		All Counties	Metro Counties	Nonmetro Counties
Location announcements (2000–2006) (%)		2.800	2.700	2.900
		(0.300)	(0.500)	(0.400)
Active ethanol plants (2000–2006) (%)		2.600	2.400	2.700
		(0.300)	(0.500)	(0.400)
PCI	Per capita income ($), 2000	22,685.688	25,758.438	21,074.404
		(102.616)	(211.173)	(91.978)
GAS	Gas stations, plus surrounding counties (2000)	258.957	455.506	155.891
		(5.546)	(13.118)	(2.969)
CATTLE	Cattle, plus surrounding counties (100,000s head)	2.007	1.553	2.245
		(0.037)	(0.048)	(0.050)
CORN	Corn, plus surrounding counties (100,000s bu)	237.750	199.087	258.023
		(7.752)	(11.751)	(10.056)
STORE	Farm product warehousing operations (LQ) (2000)	2.117	1.224	2.585
		(0.252)	(0.238)	(0.363)
ESTAB	Existing ethanol plant before 2000 (1 = yes)	0.010	0.008	0.012
		(0.002)	(0.003)	(0.003)
HERFEMP	Employment concentration index, 2000	0.121	0.141	0.110
		(0.001)	(0.001)	(0.001)
WAGE	Average wage per worker ($)	12.307	14.010	11.415
		(0.050)	(0.101)	(0.043)
HS00	% with high school diploma	77.321	80.138	75.843
		(0.158)	(0.233)	(0.199)
UTIL	Utilities location quotient (LQ), 2000	2.229	1.559	2.581
		(0.045)	(0.057)	(0.060)
DISTMET	Distance (miles to nearest metropolitan county)			65.093
				(1.047)
ROAD	Road density (road miles/county area)	0.457	0.610	0.377
		(0.005)	(0.011)	(0.004)
RAIL	Rail density (railroad miles/county area)	0.307	0.472	0.220
		(0.007)	(0.019)	(0.004)
TRUCK	Trucking companies LQ, 2000	2.076	1.561	2.345
		(0.034)	(0.034)	(0.048)
RIVER	River adjacency (1 = yes)	0.326	0.380	0.298
		(0.008)	(0.015)	(0.010)
FISC	Per capita income taxes/county expenditures, 2000	0.337	0.311	0.350
		(0.004)	(0.006)	(0.006)
TAX	State excise tax incentive (2001) (1 = yes)	0.133	0.097	0.151
		(0.006)	(0.009)	(0.008)
PRODCR	Ethanol producer credit program (2001) (1 = yes)	0.233	0.125	0.290
		(0.008)	(0.010)	(0.010)
MTBE	Methyl tertiary-butyl ether ban, 2000 (1 = yes)	0.185	0.165	0.196
		(0.007)	(0.011)	(0.009)
HLAND[a]	Heartland	0.044	0.028	0.052
		(0.010)	(0.017)	(0.012)
NOCRES	Northern Crescent	0.004	0.048	−0.019
		(0.009)	(0.018)	(0.011)
FRUIT	Fruitful Rim	−0.043	−0.009	−0.061
		(0.009)	(0.016)	(0.010)

Table 1. (Continued)

Variable		All Counties	Metro Counties	Nonmetro Counties
NOGRTPL	Northern Great Plains	−0.075	−0.13	−0.047
		(0.008)	(0.011)	(0.010)
PRGATE	Prairie Gateway	−0.006	−0.065	0.026
		(0.009)	(0.014)	(0.012)
BRANGE	Basin and Range	−0.070	−0.106	−0.05
		(0.008)	(0.013)	(0.010)
MISSPORT	Mississippi Portal	−0.080	−0.096	−0.072
		(0.008)	(0.013)	(0.010)
				1.047
N		3,064	1,054	2,010

[a] Regional variables are restricted such that $\Sigma_r \delta_r = 0$, and they represent the difference from the national average.

five with a high school diploma in each county was used to measure labor-quality effects on ethanol plant location (*HS00*) (Table 1).

Labor costs directly influence production costs and plant profits. Locations with lower labor costs have lower operating costs, which increase the attractiveness of the area for manufacturing (McNamara, Kriesel, and Deaton; Schmenner, Huber, and Cook; Smith, Deaton, and Kelch). It is hypothesized that labor costs will be negatively correlated with ethanol plant location and site selection. The 2000 average wage per worker in each county was used to measure labor cost effects (*WAGE*) (Table 1).

Plant productivity depends on labor availability. A deep labor pool requires less recruiting and is better able to provide labor for a greater diversity of firms. A diversified industry base and work force increases the likelihood of acquiring workers with the necessary skill sets to fill positions at all levels of production. A Herfindahl index was used to measure the effects of a diversified workforce on the location decision of potential ethanol plant investors (expected sign is negative) (Davis and Schluter). As the index approaches one, more individuals are employed by a single sector. The measure was calculated as $HERFEMP_i = \sum_k S_{ki}^2$, where S_{ki} indicates the shares of workers employed in the agriculture, forestry and mining, wholesale, retail, service, finance, insurance, real estate, and manufacturing sectors in a county in the year 2000.

Infrastructure Determinants (**I**)

Infrastructure consists of the physical or natural components in an economy that support community needs and business activities by creating access to regional, national, and international markets. Rainey and McNamara; Smith, Deaton, and Kelch; and Woodward considered the effect of infrastructure at the county level on manufacturing location decisions. All found that infrastructure was a significant and positive determinant of plant location choice. Ethanol producers require a reliable transport network to coordinate input procurement and distribution of ethanol and associated by-products. Transport networks include federal and state roads, railroads, and waterways capable of barge transport. Total county road network miles, including state highways and the federal interstate system, were normalized by the total square miles of the county to measure the road network potential of the county (*ROAD*). The same measure was constructed for class I and II railroad networks for each county (*RAIL*). It is expected that these transportation "density" measures will positively correlate with active ethanol plants and site announcements, holding other factors constant. County adjacency to a major river (*RIVER*) was used to measure the influence of river transport infrastructure on the location decision of ethanol producers (expected sign is positive, Table 1).

Utility services, including natural gas, electric power, and water, provide the basic infrastructure for the additional components needed to produce ethanol. Natural gas is the second largest variable cost, following feedstock acquisition (Shapouri and Gallagher). Location quotients were constructed to measure the influence of county utility services (*UTIL*) and business establishments specializing in truck transport (*TRLQ*). The North American Industrial Classification Code for the utilities sector (NAICS 22) includes natural gas distribution service, electricity generation and distribution operations, and water, sewage, and other services. The NAICS sector 484 includes long and short-distance freight trucking services. These variables are expected to be positively correlated with active ethanol plants and plant location announcements.

Local Fiscal Determinants and State Policy Incentives (**P, F**)

Fiscal policy includes the expenditure patterns and tax policies of counties and states. Higher state spending can be a benefit, but states with high corporate taxes are less attractive sites for manufacturers (Goetz). Fiscal policy influences plant site selection through the collection of taxes to finance public services (Henderson and McNamara 1997). Fiscal policy expenditures directed to worker training, school systems, educational facilities, public services, and infrastructure development can decrease the costs of production and increase the prospect of plant profitability (Bartik 1989; Kriesel and McNamara; Smith, Deaton, and Kelch).

Henderson and McNamara (1997, 2000) used county per capita taxes divided by total county expenditures per capita to measure the effects of fiscal policy on food manufacturer location decisions. County-level per capita property taxes normalized by total county expenditures per capita in 2000 were used to measure fiscal effects on the site-location decision in this study (*FISC*, expected sign is negative) (Table 1).

In their impact study of fuel oxygenation requirements on Midwest ethanol markets in the 1990s, Gallagher, Otto, and Dikeman (2000) estimated that ethanol production increased by 21% with blending mandates in place. By the end of 2000, nine states (CA, CO, CT, IA, ME, MI, MN, NE, and NY) had completely banned the oxygenated methyl tertiary-butyl ether (MTBE) (USDOE EIA). Bans on MTBE sent a clear signal to potential investors that ethanol would be the logical replacement for the fuel additive. Intuitively, a ban on MTBE, while holding the need for a comparable gas-additive constant, should induce demand for a substitute product. As such, a ban on MTBE should have a positive effect on demand for ethanol as a gas-additive. By July 2001, legislation had passed supporting state excise tax exemptions for ethanol producers in eight states (AK, CT, HI, ID, IL, IA, MN, and SD) (USDOE EIA). These measures complemented the federal excise tax (eliminated in 2004) for ethanol producers and were designed to make ethanol more competitive as a fuel additive. As a demand-side policy, it is hypothesized that the overall effects of this incentive will be greater in metropolitan counties, where there are relatively more gas stations and consumers. Also, by July of the same year, ten states (KS, MI, MN, MT, NE, ND, OK, SD, WI, and WY) had authorized ethanol producer credit incentives (USDOE EIA). This policy instrument credits the sale of corn for ethanol production. A producer credit is a supply-side policy that should have a greater effect in the nonmetropolitan, grain-producing areas. It is expected that these state-level incentives have a positive impact on attracting potential ethanol investors and are positively correlated with the location of active plants.

Regional Control Variables and Metro/ Nonmetropolitan Indicators

The ERS farm resource regions were used to control for unobserved factors associated with the first-stage location decisions of firms: Heartland, Northern Crescent, Northern Great Plains, Prairie Gateway, Eastern Uplands, Southern Seaboard, Fruitful Rim, Basin and Range, and the Mississippi Portal (USDA ERS 2000). These regions characterize the dominant agricultural commodities produced in an area, along with soil, climatic, and farm demographic attributes. The coefficients of the regional variables were restricted as $\Sigma_r \delta_r = 0$. Therefore, parameter estimates associated with these regions are differences from the overall average effect of location decisions.

It is generally assumed that nonmetropolitan areas are at a comparative advantage with respect to supply of agricultural raw materials (Capps, Fuller, and Nichols; Schluter and Lee). We tested this hypothesis by classifying counties as metropolitan or nonmetropolitan and then testing whether the slope coefficients of these groups were different. These categories were based on commuting patterns, population density, and proximity to densely populated economic "urban core" counties. Like most classification schemes it is arbitrary, but the distinction is based on information about intercounty dependencies, demographic patterns, and wider regional linkages. There are many alternative definitions of the urban-rural continuum (e.g., Isserman; USDA ERS 2003; Waldorf). We experimented with other definitions (e.g., metro-micro-rural), but found little difference between micropolitan and rural counties (i.e., the two subgroups that make up the group of nonmetropolitan counties). This result may be due to the relative sparseness of ethanol plants during 2000–2007 (i.e., n = 72 and 80 for active and newly announced plants, respectively). There were 1,054 metropolitan and 2,010 nonmetropolitan counties.

Results and Discussion

The null hypothesis that location determinants had no relation to location announcements or active plant locations was rejected at the 5% level (Wald test [W], W = 1,493 for plant announcements and 1,500 for active plant locations; degrees of freedom [df] = 38). The coefficients associated with the regional variables should not be significant if the assumption of independence between first- and second-stage location decisions is tenable. A Wald test was used to test this joint hypothesis for both models. The null hypothesis that regions did not influence the second-stage decision of ethanol plant location announcements and active plant locations could not be rejected at the 5% level (W = 8.09 and 8.46, respectively; df = 8), supporting the independence assumption between the first and second stages of the location decision. Therefore, the models were estimated without the regional fixed effects. Sensitivity analysis was performed under the hypothesis that active plant location and plant location announcements may be correlated. Plant location announcements and active plant locations were jointly estimated using bivariate probit regression to test this hypothesis. The correlation coefficient explaining cross-equation disturbances was not significant at the 10% level.

The joint test for equal slopes and intercept terms in metropolitan and nonmetropolitan counties was rejected at the 5% level in the location announcement model (W =38.72; df = 18) and at the 10% level for active plant locations (W =27.03; df = 18). The modified Moran's I-value (I) was not significant at the 5% level in either model, suggesting that the disturbance terms were not spatially correlated ($I = -0.50$ [$P = 0.69$] and -0.60 [$P = 0.72$] for the location and active plant models, respectively). Based on these diagnostics, marginal effects and location probabilities were calculated using the model specified by Equation (2) with the regional effects omitted.

Product and Input Market Determinants

Product markets had varying effects on location decisions and active plant sites, depending on whether a county was classified as metropolitan or nonmetropolitan (Tables 2 and 3). The effect of per capita income on the site-selection decision in metropolitan counties had an effect opposite of what is typically observed in manufacturing location studies, but the marginal effect was quite small. Holding other factors constant, metropolitan counties with higher per capita income levels were less likely to have attracted interest from potential ethanol plant investors from 2000 to 2006. These results may be put into perspective given that ethanol plants tend to locate in or near regions endowed with agricultural raw

Table 2. Probit Estimates of Ethanol Plant Location Announcements, 2000–2007

	Metropolitan Counties			Nonmetropolitan Counties		
Variable	Estimate	$P > \|t\|$	Marginal effect	Estimate	$P > \|t\|$	Marginal effect
CONSTANT	−3.3182	0.0340	.	−2.8096	0.0000	.
PCI	−0.0001	0.0030	−7.E–06	1.E–05	0.3590	.
GAS	0.0003	0.0960	3.E–05	−0.0015	0.1400	.
CATTLE	0.0143	0.8470		0.0945	0.0000	0.0078
CORN	0.0011	0.0000	0.0001	0.0010	0.0000	0.0001
STORE	−0.2104	0.0700	−0.0175	0.0026	0.1690	.
ESTAB				−0.4543	0.1570	.
HERFEMP	0.1329	0.9370	.	−0.1560	0.9180	.
WAGE	0.0360	0.4710	.	0.0450	0.1880	.
HS00	0.0265	0.1930	.	0.0001	0.9950	.
UTIL	−0.0325	0.5760	.	−0.0490	0.1220	.
DISTMET				−0.0022	0.1970	.
TRUCKLQ	0.0233	0.7950	.	0.0161	0.3310	.
ROAD	0.0892	0.8630	.	−0.9327	0.1090	.
RAIL	−0.0647	0.7680	.	0.9722	0.0110	0.0808
RIVER	0.4267	0.0240	0.0393	0.0913	0.5030	.
FISC	−0.5880	0.3070	.	−0.6390	0.0770	−0.0531
TAX	−0.1417	0.6470	.	−0.1559	0.4140	.
PRODCR	−0.0622	0.8330	.	0.3085	0.0600	0.0289
MTBE	0.9184	0.0000	0.1303	0.0625	0.7270	.
N			3,064 (3,072, weighted)			
Log likelihood			−312			
Mcfadden's R^2			0.21			

Note: ESTAB was omitted for metropolitan counties because of multicollinearity.

materials. These areas do not typically have high per capita incomes, unlike the large metropolitan conglomerations of the East and West Coasts.

Access to feedstock sources is always an important consideration with respect to ethanol production. Corn availability in a given county and its surrounding neighbors was the strongest location determinant for metropolitan and nonmetropolitan counties with respect to active ethanol production and potential sites (Tables 2 and 3). The marginal effect of the variable was relatively small, but the t test was largest compared to the other variables ($t = 6.76$, $P < 0.0001$). However, access to inputs may be stymied by nearby competitors in nonmetropolitan counties. At the 15% level ($P = 0.12$), holding other factors constant, counties with an established ethanol plant were less likely to have received a plant location announcement from 2000 to 2006 given an increase in the number of plants located in a county before 2000 (Table 3). The predominant feedstock in the Midwest is corn, but grain sorghum is an alternative feedstock available in other regions, including Kansas and Oklahoma. As a sensitivity test, the 2000 sorghum production, including sorghum produced in surrounding counties, was included in the location model. The variable was not a significant attractor at the 10% level for metropolitan or nonmetropolitan counties ($P = 0.13$ and 0.90, respectively). We surmise that these results stem from that fact that most sorghum production occurs in Kansas and Oklahoma, but most of the plant location announcements occurred in Iowa, Illinois, and other Heartland states.

Final demand markets for ethanol and DG are important location determinants (Tables 2 and 3). The "microregion" variable, which measures the effects of retail gasoline stations

Table 3. Probit Estimates of Active Ethanol Plant Locations, 2000–2007

	Metropolitan Counties			Nonmetropolitan Counties		
Variable	Estimate	$P > \|t\|$	Marginal effect	Estimate	$P > \|t\|$	Marginal effect
CONSTANT	−2.7096	0.0800	.	−3.3700	0.0010	.
PCI	0.0000	0.9990	.	3.E–05	0.1230	.
GAS	0.0005	0.0040	0.0001	−0.0011	0.2810	.
CATTLE	0.0489	0.3150	.	0.0618	0.0230	0.0076
CORN	0.0005	0.0030	0.0001	0.0007	0.0000	0.0001
STORE	0.0029	0.7080	.	−0.0187	0.2900	.
ESTAB			.	−0.6652	0.1260	.
HERFEMP	−2.9338	0.2970	.	1.4845	0.4680	.
WAGE	0.0129	0.7090	.	−0.0832	0.0870	−0.0100
HS00	0.0073	0.7120	.	0.0146	0.1750	.
UTIL	−0.0787	0.2290	.	−0.0454	0.1760	.
DISTMET			.	−0.0029	0.1450	.
TRUCKLQ	0.0193	0.7830	.	−0.0013	0.9730	.
ROAD	−0.2675	0.4940	.	0.0640	0.9150	.
RAIL	0.0976	0.5370	.	0.6202	0.1510	.
RIVER	−0.0299	0.8740	.	0.1343	0.3560	.
FISC	−0.1408	0.7060	.	0.0598	0.8070	.
TAX	−0.0653	0.7900	.	0.3614	0.0400	0.0475
PRODCR	0.1666	0.5180	.	0.1619	0.3530	.
MTBE	0.1492	0.5720	.	0.0281	0.8590	.
N	3,064 (3,067, weighted)					
Log likelihood	−300					
Mcfadden's R^2	0.24					

Note: ESTAB was omitted for metropolitan counties because of multicollinearity.

on plant location, was strongly associated with active ethanol plants in metropolitan counties (Table 3) and ethanol plant announcements in metropolitan counties. All else held constant, potential markets for DG were also positively correlated with active ethanol plants in nonmetropolitan counties, but the marginal effects were quite small (Table 3). Metropolitan counties specializing in storage and warehousing of agricultural products appear to be at a disadvantage with respect to attracting interest from potential ethanol plant investors. One possible explanation is that metropolitan counties do not typically specialize in warehousing agricultural products because they are sinks for final demand.

Labor Determinants

In general, labor determinants, including wages, labor quality, and a diverse pool of skilled labor, do not appear to be important considerations for potential ethanol plant investors. However, wages were negatively correlated with active plant locations in nonmetropolitan counties (Table 3). Given a 1% increase in average wage per worker, the likelihood of having an active plant decreased by 1%.

Infrastructure Determinants

Surprisingly, relatively few infrastructure proxies were correlated with plant location announcements and active plant locations (Tables 2 and 3). Metropolitan counties adjacent to a navigable river were, holding other factors constant, 3% more likely to attract potential investment. Nonmetropolitan counties with well-developed rail transport systems (as measured by railroad miles over county square miles) had a comparative advantage over other counties with respect to attracting potential ethanol plant investment.[1] Given a 1% increase in this ratio, nonmetropolitan counties were 8% more likely to attract the interest of potential investors. Access to utility services did not appear to be a factor with respect to plant location announcements in metropolitan or nonmetropolitan counties from 2000 to 2006.

Local Fiscal Determinants and State Policy Incentives

Nonmetropolitan counties located in states with excise tax exemption incentives in place before July 2001 were, all else equal, about 5% more likely to have an active ethanol plant (Table 3). Other state policy instruments and local fiscal characteristics were not associated with active plant sites. Fiscal policy and state incentives were also related to plant location announcements in metropolitan and nonmetropolitan counties. Metropolitan counties located in states where MTBE was banned in 2000 (or earlier) were 13% more likely to attract interest from potential ethanol plant investors. Nonmetropolitan counties located in states supporting producer credit incentives were 3% more likely to have attracted interest from potential ethanol plant investors from 2000 to 2006 (Table 2). Local tax burden was negatively correlated with plant location announcements in nonmetropolitan counties. Given a 1% increase in this ratio, the likelihood of attracting interest from potential investors decreased by 5%.

Location Effects of MTBE Bans and Producer Incentives

As a sensitivity analysis, microregional access to corn feedstock was allowed to vary while other variables were held constant at their group means for metropolitan and nonmetropolitan counties (Figure 2). The probability of a metropolitan county attracting potential investment located in states that had banned MTBE by 2000 was significantly higher than metropolitan counties in states that permitted the use of the additive. The comparative advantage was significant at the 90% level until about the 1,250 million bu corn threshold. At higher levels of production, the policy instrument appears to have conferred no clear advantage to metropolitan counties. In nonmetropolitan counties, the comparative advantage resulting from producer's credit programs was even more sensitive to access to corn. At the 750 million bu corn production level, the probability of attracting potential investment in nonmetropolitan counties participating in states with producer credit programs was not different from other nonmetropolitan counties located in states without such programs. In both sensitivity analyses, the attractiveness of county-as-site increased given state policy instruments, but the predicted increase in the likelihood of attracting such investment was relatively small. In both scenarios, access to feedstock materials remained the driving factor in the location decision.

Distribution of Ethanol Plant Location Clusters

The spatial distribution of the estimated site-selection probabilities suggests that some counties in southern California, the Oklahoma and Texas panhandle regions, eastern Illinois, eastern Colorado, southeastern South Dakota, and western Nebraska may have comparative advantages with respect to attracting new ethanol plant investment (Figure 1). Some high-probability location clusters are also evident in central Michigan and northeastern Ohio. In general, these regions are

[1] The rail network variable may not be capturing transportation cost difference. While rail network density in a county may suggest that rail lines are accessible, it does not measure costs due to distance between feedstock production areas and potential processing sites. Ethanol may be shipped at single-car rail rates, but the feasibility of bringing in corn or other feedstock sources depends on the ability of an investor to locate near unit-train unloading facilities. Railroad companies typically control the locations of unloading facilities, and these facilities must have the capacity to switch on to main rail lines. To fully capture this determinant, information about unit train unloading facilities would be useful. To our knowledge, such a data set is not publicly available.

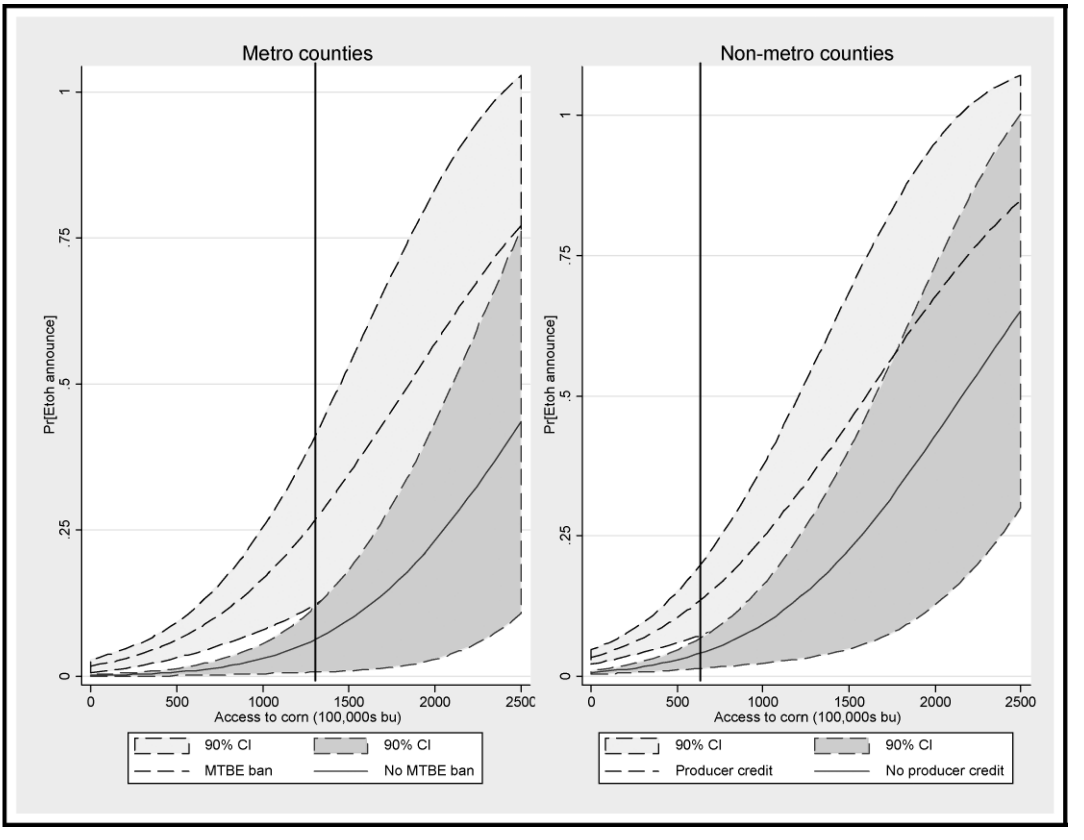

Figure 2. MTBE Ban and Producer Credit Policy Variable Sensitivity Analysis in Metropolitan and Nonmetropolitan Counties, Respectively
Note: All Other Variables Are Evaluated at Respective Group Means. The Vertical Lines Indicate Where the Predicted Responses as Functions of Access to Corn Feedstock Are Not Significantly Different

endowed with feedstock resources and co-product market potential.

The global Moran's *I* was 0.67 for location probabilities, and it was significant at the 1% level, suggesting that clustering of counties sharing similar comparative advantage with respect to attracting ethanol plant investment is significant. Local Indices of Spatial Association (Anselin) were estimated based on the site announcement probabilities. These indices isolate clusters of counties that share probabilities of similar magnitude. Clustering is evident throughout central and northern Illinois, Minnesota, and Iowa because of relatively cheap corn and potential DG markets in North and South Dakota. Clustering is also evident in central and eastern Nebraska and the panhandles of Oklahoma and Texas because of cattle feed lots or other livestock operations. Counties that are located in these regional clusters have, holding other factors constant, a comparative advantage with respect to attracting ethanol production facilities using corn feedstock, and where there are potential markets for DG.

Nonmetropolitan counties have a comparative advantage with respect to attracting potential ethanol plant investment. Most high-probability clusters (64%) are composed of nonmetropolitan counties (Figure 3). A more detailed breakdown of metropolitan and nonmetropolitan counties revealed that rural counties not adjacent to metropolitan areas were competitive with respect to attracting interest from potential ethanol plant investors. These counties provide access advantage with respect to agricultural raw materials and potential markets for DG.

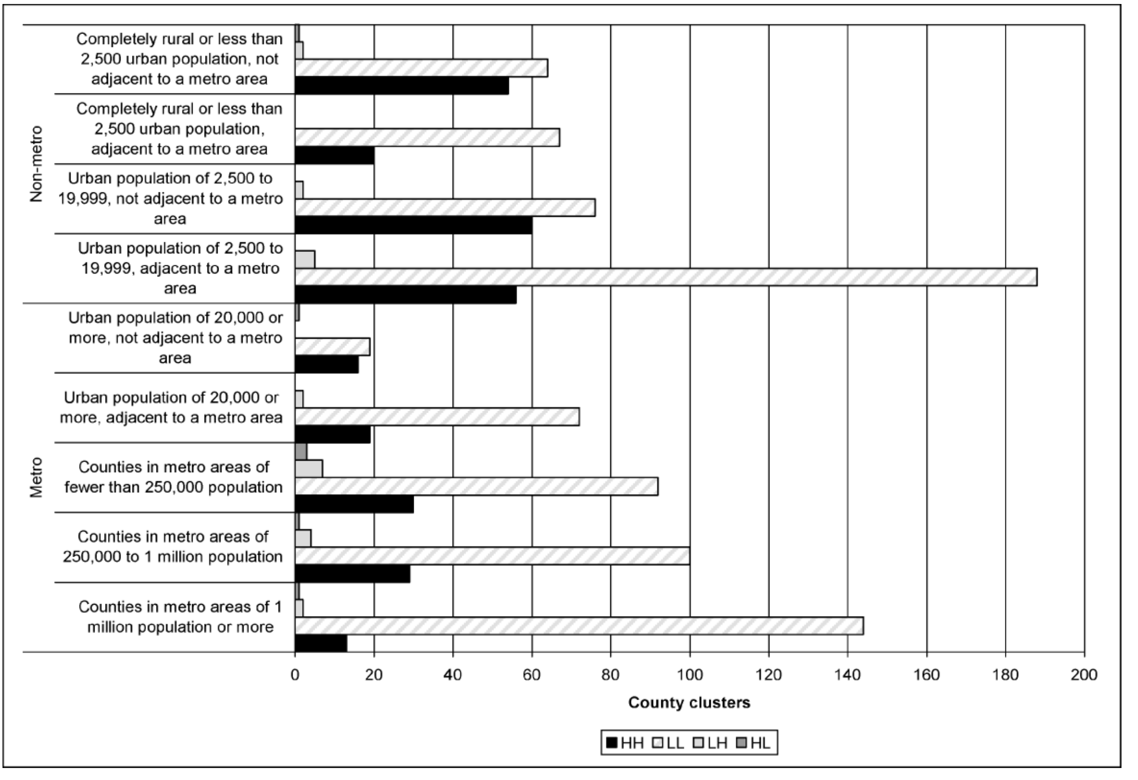

Figure 3. Distribution of Location Probability Clusters across an Urban-Rural Continuum
Note: HH Is High-Probability County Clusters, LL Is Low-Probability County Clusters, HL Is High-Probability Counties Surrounded by Low-Probability Counties, LH Is Low-Probability Counties Surrounded by High-Probability Counties

Other nonmetropolitan counties with urban populations not adjacent to metropolitan areas, and nonmetropolitan counties with urban populations located next to metropolitan counties appear to be competitive as well. These counties also have an access advantage to feedstock sources, as well as final demand markets for ethanol.

Conclusions

This analysis used probit regression and spatial clustering techniques to isolate the location determinants that were important with respect to attracting ethanol plant investment. Nonmetropolitan counties, including very remote, rural counties, have comparative advantages with respect to attracting ethanol plant investment because of their access advantage to feedstock resources and coproduct markets. Access to feedstock is the primary driver behind the ethanol plant location decision. In addition, access to coproduct markets and transport infrastructure is also important. Local fiscal policy and state incentives influenced the location decisions of potential ethanol producers during 2000–2007. Labor determinants were less important. Some policy instruments may have the side effect of increasing the attractiveness of some counties as potential production sites.

These findings are a first step toward understanding the interplay between ethanol plant location and the local factors that provide a comparative advantage to counties considering grain-based ethanol plant recruitment as a development strategy. While the results of the cluster analysis appear encouraging for some remote rural areas, they should be kept in perspective. First, state subsidies have varied considerably over time, and have been (and continue to be) a major driver in ethanol plant location decisions at local levels. Also, several of the state subsidies have been adjusted since 2000. The empirical model does not adequately capture these dynamics. Future studies could focus on the effects of the level and duration of such incentives on ethanol plant investment. Second, while input supply is certainly the dominant concern facing ethanol producers, potential investment flow for corn-based ethanol production may also be influenced by the corn basis price. Inclusion of a proxy for corn basis price may shed some light on the way in which potential investment flow is directly influenced by input cost. The difference between the costs of procuring input locally versus transporting it to the facility may be an important consideration. Lastly, although ethanol production is not a new technology or a new type of "value-added" agriculture, the industry is in its infancy. As profit margins decrease, there will be fewer entrants into the market. The flurry of location activity observed from 2000 to 2007 will inevitably give way as new technologies emerge, demand for ethanol products expands, alternative feedstocks are introduced, and policy instruments evolve. Plants less efficient in penetrating coproduct markets and competing for feedstock sources will be replaced by operations able to take advantage of market potential, withstand price volatility, and exploit scale economies. This replacement implies, given current market projections of continued expansion, some consolidation in areas where the feedstock is easily transported and niche marketing/artisanal production becomes less viable due to profit-margin decline and the parallel increase in plant efficiencies. Inevitably, the local comparative advantage of feedstock-supplying counties may shift to more regional levels as larger plants import corn to meet production targets, and local grain feedstock supply is exhausted. As corn feedstock supply decreases, alternative lignocellulosic materials will become increasingly important, providing opportunities to other rural communities as potential sites for ethanol production.

[Received May 2007; Accepted July 2007.]

References

Althoff, K., C. Ehmke, and A.W. Gray. "Economic Analysis of Alternative Indiana State Legislation on Biodiesel." Department of Agricultural Economics Report OFH63, Purdue University, West Lafayette, IN, 2003.

Anselin, L. "Local Indicators of Spatial Association." *Geographical Analysis* 27(1995):93–115.

Bain, J.S. *Barriers to New Competition*. Cambridge, MA: Harvard University Press, 1956.

Baker, A., and S. Zahniser. "Ethanol Reshapes the Corn Market." *Amber Waves* (April 2006):30–35.

Bartik, T.J. "Business Location Decisions in the United States: Estimates of the Effects of Unionization, Taxes, and Other Characteristics of States." *Journal of Business and Economic Statistics* 3,1(1985):14–22.

———."Small Business Start-Ups in the United States: Estimates of the Effects of Characteristics of States." *Southern Economic Journal* 55,4(1989):1004–18.

Capps, O., Jr., S.W. Fuller, and J.P. Nichols. "Assessing Opportunities in Food and Fiber Processing and Distribution." *American Journal of Agricultural Economics* 70,2(1988):462–68.

Connor, J.M., and W. Schiek. *Food Processing: An Industrial Powerhouse in Transition,* 2nd ed. New York, NY: John Wiley and Sons, 1997.

Coughlin, C., J.V. Terza, and V. Arromdee. "State Characteristics and the Location of Foreign Direct Investment within the United States." *The Review of Economics and Statistics* 73,4(1991):675–83.

Davidson, R., and MacKinnon, J.G.. *Estimation and Inference in Econometrics*. Oxford: Oxford University Press, 1993.

Davis, D.E., and G.E. Schluter. "Labor-Force Heterogeneity as a Source of Agglomeration Economics an in Empirical Analysis of County-Level Determinants of Food Plant Entry." *Journal of Agricultural and Resource Economics* 30,3(2005):480–501.

De La Torre Ugarte, D., B. English, K. Jensen, C. Hellwinckel, J. Menard, and B. Wilson. *Economic and Agricultural Impacts of Ethanol and Biodiesel Expansion.* Department of Agricultural Economics, University of Tennessee, Internet site: http://web.utk.edu/~aimag/pubimpact.html (Accessed July 26, 2007).

Dhuyvetter, K.C., T.L. Kastens, and M. Boland. "The U.S. Ethanol Industry: Where Will It Be Located in the Future." Agricultural Issues Center, University of California, Davis, CA. November 2005.

Doering, O. "Ethanol and Energy Policy." Report ID-340, Working Paper. Department of Agricultural Economics, Purdue University, West Lafayette, IN, 2006.

English, B.C., D. De La Torre Ugarte, M. Walsh, C. Hellwinckel, and J. Menard. "Economic Competitiveness of Bioenergy Production and Effects on Agriculture of the Southern Region." *Journal of Agricultural and Applied Economics* 38,2(2006):389–402.

English, B.C., D. De La Torre Ugarte, K. Jensen, C. Hellwinckel, J. Menard, B. Wilson, R. Roberts, and M. Walsh. *25% Renewable Energy for the United States by 2025: Agricultural and Economic Impacts.* Department of Agricultural Economics, University of Tennessee, Internet site: http://web.utk.edu/~aimag/pubimpact.html (Accessed July 26, 2007).

English, B.C., J. Menard, and D. De La Torre Ugarte. *Using Corn Stover for Ethanol Production: A Look at the Regional Economic Impacts for Selected Midwestern States.* Department of Agricultural Economics, University of Tennessee, Internet site: http://web.utk.edu/~aimag/pubimpact.html (Accessed July 26, 2007).

ESRI (Environmental Sensitivities Research Institute). *Environmental Sensitivities Research Institute*. Internet site: http://www.esri.com/ (Accessed July 26, 2007).

Ethanol Across America. *Economic Impacts of Ethanol Production*. Internet site: http://www.ethanolacrossamerica.net/CFDC_EconImpact.pdf (Accessed July 26, 2007).

Evans, M. *Economic Impacts of the Demand for Ethanol.* Kellogg School of Management, Northwestern University, Evanston, IL, 1997.

Gallagher, P., D. Otto, and M. Dikeman. "Effects of an Oxygen Requirement for Fuel in Midwest Ethanol Markets and Local Economies." *Review of Agricultural Economics* 22,2(2000):292–311.

Goetz, S. "State- and County-Level Determinants of Food Manufacturing Establishment Growth: 1987–1993." *American Journal of Agricultural Economics* 79,3(1997):838–50.

Henderson, J.R., and K.T. McNamara. "Community Attributes Influencing Local Food Processing Growth in the U.S. Corn Belt." *Canadian Journal of Agricultural Economics* 45(1997): 235–50.

———."The Location of Food Manufacturing Plant Investments in Corn Belt Counties." *Journal of Agricultural and Resource Economics* 25,2(2000):680–97.

Isserman, A.M. "In the National Interest: Defining Rural and Urban Correctly in Research and Public Policy." *International Regional Science Review* 28,4(2005):465–99.

Kelejian, H., and Prucha, I.R.. "On the asymptotic distribution of the Moran I-test statistic with applications." *Journal of Econometrics* 104(2001): 219–57.

Kenkel, P., and R.B. Holcomb. "Challenges to Producer Ownership of Ethanol and Biodiesel Production Facilities." *Journal of Agricultural and Applied Economics* 38,2(2006):369–75.

Kriesel, W., and K.T. McNamara. "A County-Level Model of Manufacturing Plant Recruitment with Improved Industrial Site Quality Measurement." *Southern Journal of Agricultural Economics* 31,1(1991):121–27.

Lambert, D., K. McNamara, and M. Garrett. "Food Industry Investment Flows: Implications for Rural Development." *Review of Regional Studies* 36,2(2006):140–62.

Leistritz, F.L. "Agribusiness Firms: Location Determinants and Economic Contribution." *Agribusiness* 8,4(1992):273–86.

Leistritz, F.L., N.M. Hodur, D.M. Senechal, M.D. Stowers, D. McCalla, and C.M. Saffron. "Biorefineries Using Agricultural Residue Feedstock in the Great Plains." AAE Report #07001, Working Paper. North Dakota State University Agricultural Experiment Station, Fargo, ND, 2007.

Lopez, R.A., and N.R. Henderson. "The Determinants of Location Choices for Food Processing Plants." *Agribusiness* 5,6(1989):619–32.

McAfee, R.P. "What is a Barrier to Entry?" *American Economic Review* 94,2(2004):461–65.

McNamara, K.T., W.P. Kriesel, and B.J. Deaton. "Manufacturing Location: The Impact of Human Capital Stocks and Flows." *Review of Regional Studies* 18,1(1988):42–48.

Munroe, D.K., J. Southworth, and C.M. Tucker. "The Dynamics of Land-Cover Change in Western Honduras: Exploring Spatial and Temporal Complexity." *Agricultural Economics* 27,3(2002):355–69.

Novack, N., and J. Henderson. "Can Ethanol Power the Rural Economy?" *The Main Street Economist* 2,1(2007):1–6.

Parcell, J.L., and P. Westhoff. "Economic Effects of Biofuel Production on States and Rural Communities." *Journal of Agricultural and Applied Economics* 38,2(2006):377–87.

Rainey, D.V., and K.T. McNamara. "Taxes and Location Decision of Manufacturing Establishments." *Review of Agricultural Economics* 21,1(1999):86–98.

Schluter, G., and C. Lee. "Can Rural Employment Benefit from Changing Labor Skills in U.S.

Processed Food Trade?'' *Rural America* 17,4(2002):38–43.

Schmenner, R.W., J.C. Huber, and R.L. Cook. "Geographic Differences and the Location of New Manufacturing Facilities." *Journal of Urban Economics* 21,1(1987):83–104.

Shaffer, R., S. Deller, and D.W. Marcouiller. *Community Economics: Linking Theory and Practice,* 2nd ed. Oxford: Blackwell Publishing, 2004.

Shapouri, H., and P. Gallagher. *USDA's 2002 Ethanol Cost-of-Production Survey*. ESCS for. Agricultural Economics Report 841. Washington, D.C: U.S. Department of Agriculture, July 2005.

Smith, E.D., B.J. Deaton, and D.R. Kelch. "Location Determinants of Manufacturing Industry in Rural Areas." *Southern Journal of Agricultural Economics* 10,1(1978):23–32.

Swenson, D., and L. Eathington. "A Summary of Findings: Determining the Regional Economic Values of Ethanol Production in Iowa Considering Different Levels of Local Investment." Report BIOE2006-01, Working Paper. Department of Agricultural Economics, Iowa State University, Ames, IA, 2006.

Urbanchuk, J.M., and J. Kapell. *Ethanol and the Local Community* Renewable Fuels Association, Internet site: http://www.ethanolrfa.org/objects/documents/120/ethanol_local_community.pdf (Accessed July 26, 2007).

U.S. Department of Agriculture. *USDA Agricultural Projections to 2016*. Long-Term Projections Report OCE-2007-1. Washington, D.C: U.S. Department of Agriculture, February 2007.

U.S. Department of Agriculture, Economic Research Service (ERS). *Farm Resource Regions*. 2000. Agricultural Information Bulletin Number 760, 2. Internet site: www.ers.usda.gov/publications/aib760/aib-760.pdf (Accessed July 26, 2007).

———. *Measuring Rurality: What is a Micropolitan Area?* Agricultural Briefing Room, 2003. Internet site: www.ers.usda.gov/Briefing/Rurality/MicropolitanAreas/ (Accessed July 26, 2007).

U.S. Department of Commerce, Bureau of the Census. *United States Census*. Washington, D.C: U.S. Department of Commerce, June 2000.

U.S. Department of Energy, Energy Information Administration (DOE EIA). *Biofuels for the State; Helping the Economy and the Environment*. Washington, D.C: U.S. Department of Energy, September 2001.

Vesecky, M., and D. Lins. "Factors Influencing Expansion and Contraction Decisions by Illinois Agribusiness Firms." *Agribusiness* 11,5(1995):405–13.

Waldorf, B. *What Is Rural and What Is Urban in Indiana?*. Purdue Center for Regional Development Report #4, Purdue University, Internet site: www.purdue.edu/dp/pcrd/pdf/PCRD-R-4.pdf (Accessed July 26, 2007).

Woodward, D.P. "Locational Determinants of Japanese Manufacturing Start-Ups in the United States." *Southern Economics Journal* 58,3(1992):690–708.