The Journal of
Regional
Analysis
& Policy

JRAP 41(2): 148-167.

The Effect of Ethanol Plants on Residential Property Values: Evidence from Michigan

Timothy R. Hodge
Michigan State University - USA

Abstract. Since the mid 1990s, ethanol production has increased at an exponential rate. While politicians and the industry have praised the positive effects of ethanol facilities, it is important to explore the potential negative impacts. This study examines one negative effect that is not yet fully understood: the impact ethanol plants have on the value of residential property located near a new ethanol facility. To meet this objective, sales data for residential properties sold between 1999 and 2009 from two ethanol communities in Michigan and the hedonic method are used to evaluate the impact on property values over time and across homes in each community. Conclusions confirm that ethanol plants may have large negative effects, depressing the value of homes as much as 18% and as far as two miles away. However, these results may not be universal as conditions, tastes, and preferences differ across space and time.

1. Introduction

Ethanol production in the United States has steadily been on the rise since the mid 1990s (Figure 1). As of January 2010, there were 189 operational ethanol plants in the United States with capacity totaling over 13 billion gallons per year. This capacity is expected to exceed 14.4 billion gallons per year once current projects are complete.[1]

As noted by Hahn and Cecot (2009), the continued growth of the ethanol industry is primarily the result of politicians and scientists seeing ethanol as a way to promote environmental and energy security goals. To stimulate the production and use of ethanol to meet these goals, significant strides in production levels have been spurred by generous subsidies and government mandates at both national and state levels (Cotti and Skidmore, 2010). Recent estimates highlight that incentives are accomplishing their intended effect, as the industry displaced the need for 364 million barrels of oil (approximately 5%) in 2009 (Urbanchuk, 2010).

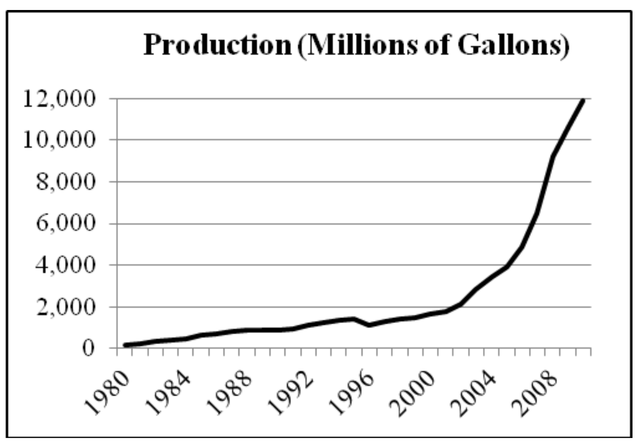

Figure 1. Historical ethanol production (RFA).

In addition to the environmental and political benefits associated with the ethanol boom, it is often cited that this growth is benefiting rural America by reshaping its economic base. As Don Cumpton, the

[1] See the Renewable Fuels Association (RFA) website, http://ethanolrfa.org, for production details.

director of economic development in Hereford, Texas, stated in an interview with the New York Times, "These projects are bringing 100 new jobs to our town. It's not as if Dell computer's going to be setting up shop here. We'd be nuts to turn something like this down" (Barrionuevo, 2006). Recent calculations validate this claim, highlighting numerous benefits to both local and national sectors of the economy. In a report prepared for the Renewable Fuels Association, Urbanchuk (2010) estimated that the 2009 production levels supported nearly 400,000 jobs in all sectors of the economy, contributed $53.5 billion to GDP, and added $16 billion to household income. Despite the allure of ethanol, the industry is not without skeptics, and researchers in a number of fields are analyzing the industry to fully understand its impact. Four general conclusions highlighting the negative effects of ethanol production include: increasing grain and food prices in local and world markets (McNew and Griffith, 2005; Runge and Senauer, 2007); environmental degradation (Pimental, 1991; Pimental, 2003; Niven, 2005; Searchinger et al., 2008); inefficient production (Pimental, 2003); and costs exceeding benefits (Gardner, 2007; Hahn and Cecot, 2009). Although research highlighting the industry's negative impact is growing, one subject with little exposure is the effect of ethanol plants on surrounding residential property values, a topic worth our attention if we are to fully capture the economic costs of the industry.

It is reasonable to anticipate that ethanol plants will have a negative effect on neighboring property values. The odor emitted by a plant is considered offensive, even nauseating, to some (Meersman, 2001). On this basis alone, ethanol plants may depress property values as homebuyers may require a discounted price to live with the smell.[2] Beyond odor, there are two additional negative externalities that may depress property values: 1) toxic emissions which could escape the plant, requiring evacuation for a large radius surrounding the plant, and 2) increased truck traffic with associated noise and safety concerns.

This study recognizes the externalities ethanol plants may impose on residents and provides the first property level analysis examining the change in residential property values associated with the presence of a new ethanol plant. To meet this objective, property level data has been collected from two Michigan communities that currently have operating facilities. The two communities in this study represent the range of communities in which plants are locating across the country: one is a small farming town with a low amount of vegetation, other than crops, and little pre-existing industry (Caro), while the other is more populated with a high amount of vegetation and other established industrial sites (Marysville).

The data compiled includes more than 600 residential sales in each community over a ten-year period (1999-2009), and the analysis relies on the well-established hedonic method to evaluate the impact on property values over time and across homes in each community. Using the ten-year period, this study provides a unique hedonic analysis by directly comparing properties sold prior to each plant's production with those sold after operations begin. In addition, use of data over the ten-year period provides greater confidence that any observed negative effect is truly the effect of the ethanol plant and not some pre-existing, unobserved factor. Conclusions confirm that ethanol plants may have a large impact on property values, depressing the value of homes as much as 18% and as far as two miles away. However, this conclusion may not be universal, as consumer tastes and preferences differ across space and time. In addition, conditions surrounding residential properties may limit the impact of an ethanol plant, including pre-existing industry and the inability to see the plant.

The following section provides an overview of all studies examining the effect of ethanol plants on neighboring property values, highlighting the need for an in-depth, property-level analysis. Section 2 also provides a review of hedonic studies that evaluate the negative externalities or projects at different stages. Section 3 focuses on the hedonic method and how it allows researchers to monetize different property attributes, including negative externalities. The specific models used in the present study are also discussed in Section 3. Details regarding the two cities and the data used in this study are discussed in Section 4. The results are presented in Section 5, and Section 6 offers concluding remarks.

2. Literature review

2.1 Ethanol industry

The negative effects of the ethanol industry that have been examined by researchers include: costs

[2] Studies that have measured negative effects of smell and air quality on property values include Harrison and Rubinfeld (1978), Nelson (1978), Zabel and Kiel (2000), and Saphores and Aguilar-Benitez (2005).

exceeding benefits, increasing food and grain prices in both local and world markets, environmental degradation, production inefficiency, and effects on neighboring property values. Of key interest in this study is the effect of an ethanol plant on neighboring property values. To date, four studies have examined the effect of an ethanol plant on neighboring property values, and the effect on residential properties is not yet well understood. Of these four studies, only two are directly relevant to the issue of residential properties; the other two studies examine the impact of ethanol plants on agricultural land (Henderson and Gloy, 2008; Blomendahl and Johnson, 2009).[3]

The first study highlighting the impact of an ethanol plant on residential property values was conducted in 2007 by a consulting firm hired by the city of Portsmouth, Virginia. City officials were concerned about the potential impact that a 216 million gallon per year (MGY) ethanol plant would have on local property values. Using a few Texas communities as a baseline, the report concluded that housing values could decline between eight and forty-six percent for homes within a two-mile radius of the plant (Hoyer and Saewitz, 2007). Three major shortcomings of this study are highlighted by Turnquist, Fortenbery, and Foltz (2008). First, the methodology of the consulting firm was not described in the report, making the conclusions difficult to evaluate. Second, the communities the firm used were not named. Third, there exists no evidence of any public, peer-reviewed assessment of ethanol plant effects in Texas or anywhere else. Beyond these issues, there is an additional concern with regards to the validity of this report. According to the 2008 Energy Report of Texas, the first operational ethanol plant in Texas went online in early 2008.[4] Therefore, a 2007 report estimating the impact of an ethanol plant in Texas cannot measure the effects of an operational plant.

Given the shortcomings of the 2007 report, the remaining investigation by Turnquist, Fortenbery, and Foltz (2008) is the only public source document that offers an examination of the effect of ethanol plants on residential properties. In their study, the authors' evaluation of the effect ethanol plants have on neighboring property is twofold. First, the authors analyze the impact of a plant on the rate of agricultural land conversion. Their expectation is that as the value of agricultural land increases because of expected commodity price increases, the rate of agricultural land conversion to other uses will diminish (relative to other communities). Second, the authors investigate the impact of an ethanol plant on residential property values.

To undertake their analysis, the authors examined four ethanol facilities in Wisconsin (all operational by 2006) and collected municipal level tax assessment data from 2000 to 2006. To capture the effect, the four ethanol plants were geographically located and zones of two, ten, twenty-five, and fifty miles around each plant were created. These zones acted as representative distances from the plant to each municipality. The authors note that municipalities closest to the plant experienced growth rates of 50% while municipalities in the rest of the state experienced growth rates of 80%. Testing the differences between the rates of growth among municipalities, the authors were unable to confirm that the ethanol communities experienced less growth, because the differences were not statistically significant. In conclusion, the authors suggest that some properties within the closest municipality may have experienced adverse effects from the plant's existence; however, any potential negative effect was offset at the municipal level. The authors deduce that if any effect on residential land is to be determined, a detailed analysis at the sub-municipal level is needed.

2.2 Project Impacts at Different Stages

Three hedonic studies could be found that explicitly measure the impact of projects at different stages. First, Smolen, Moore, and Conway (1992) examined the impact of an existing hazardous waste site and the impact of a proposed hazardous waste site. The authors conclude that properties in the community with the proposed plant were not impacted while properties in the community having an existing waste site were impacted between $9,000 and $14,000 for each additional mile up to 2.6 miles. This is different from the present study, however, as different communities were directly compared. Differences between communities may exist, and

[3] The two studies examining farmland are irrelevant to the present study since the value of residential property is based on its housing attributes while agricultural land is valued on its anticipated future earnings. From this difference, farmland prices are expected to increase with the introduction of an ethanol plant since higher expected returns are anticipated with increased demand for local corn (McNew and Griffith, 2005).

[4] See http://www.window.state.tx.us/specialrpt/energy/ .

direct comparisons may not be made unless all differences are accounted for.[5]

Second, McMillen and Thorsnes (2003) examine the impact of a smelter on property values at different phases in Tacoma, Washington. Specifically, the authors examined the impact of the smelter during the following four stages: 1) operational, 2) closing, 3) Superfund site designation, and 4) cleanup. McMillen and Thorsnes concluded that the discount associated with proximity to the smelter converted to a premium once the site was closed and designated as a Superfund site. The authors state that this outcome was observed because the smelter was located in an otherwise attractive location. McMillen and Thornses use a technique similar to the one employed in the present study; however, they examine the removal of a negative externality rather than the introduction of a negative externality.

Finally, Kiel and McClain (1995) examined the impact of an incinerator on home sales during different time periods in North Andover, Massachusetts. The stages that were examined include: pre-rumor, rumor, construction, beginning operations, and continued operations. The authors found that the incinerator had no impact until the construction phase, at which time the property values increased approximately $2,300 for each additional mile from the plant. Once the incinerator began operations, the impact was much larger ($8,100 per mile) and over time the impact slightly decreased ($6,600 per mile). This is directly comparable with the current study; however, the current study takes Kiel and McClain's general results into consideration and implements two time periods (pre- and post-production).

3. Methods

3.1. Hedonic approach

Over the past forty years, there has been considerable discussion concerning theoretical and empirical methods to estimate the price of housing attributes (including externalities). The approach that has been widely used is hedonic price analysis. To determine the impact of an ethanol plant on neighboring residential property values, I follow the general theoretical approach outlined by Rosen (1974).[6]

As with any good, a housing unit may be described as a vector of n objectively measured attributes ($H = h_1, h_2,..., h_n$). Such attributes encompassed in a housing unit include the characteristics of the structure (i.e., square footage, number of bedrooms, number of bathrooms, age, etc.), the land the structure is on, and the location in which it exists. Beyond forming the housing unit, each attribute also has its own implicit price, and it is the sum of these prices that determines how much a house is worth ($p_H = \sum_{i=1}^{n} p_i$) (Brasington and Hite, 2005; Kashian, Eiswerth, and Skidmore, 2006). However, the price of each attribute is not readily observed as a house cannot be disaggregated and sold in separate markets. Therefore to obtain the price of a given attribute, one can use data on the final price of the house and variables that characterize the attributes embodied in the unit to derive the hedonic price function [$P(H)=F(h_1, h_2,..., h_n)$]. This function, in turn, allows empirical estimation of the implicit marginal price of a given attribute (Palmquist, 1984). Quoting Rosen (1974, pg. 34): "Econometrically, implicit prices are estimated by the first-step regression analysis (product prices regressed on characteristics) in the construction of hedonic price indexes" [$\hat{P}(H)$]. Using the first-step regression, the implicit marginal price of the ith component is defined as $\hat{p}_i = \partial \hat{P}(H)/\partial h_i$ (Goodman, 1978).

3.2. Model

The model in this study will analyze the impact of an ethanol plant using two approaches. The first approach measures distance of each property from the ethanol plant as a continuous variable. This approach is illustrated by the following equation:

$$\begin{aligned} PRICE_i = \alpha + \sum_{j=1}^{m} \beta_j X_{ij} + \sum_{l=1}^{n} \gamma_l L_{il} + \delta_1 preD_i \\ + \delta_2 DISTpre_i + \delta_3 DISTpost_i \\ + \delta_4 DISTpost_i^2 + \sum_{t=1}^{k} \theta_t TIME_{it} + \varepsilon_i \end{aligned} \quad (1)$$

where $PRICE_i$ represents the real sales price of each house (i),[7] X_{ij} represents chosen structural attributes, L_{il} represents chosen neighborhood attributes, $preD_i$ is an indicator variable representing properties sold

[5] One key difference between communities is the price consumers may be willing to pay for a given bundle of attributes (or even a single attribute). These differ as tastes and preferences change across time and space (Sirmans et al., 2005).

[6] Although Rosen was not the first to employ hedonic pricing techniques to estimate implicit prices of goods (Haas, 1922a; Wallace, 1926; Court, 1939; Ridker and Henning, 1967), he was the first to support interpretation and estimation through a well-defined theoretical model.

[7] Prices will be converted to 2009 dollars using the Consumer Price Index (CPI).

before a plant began production, $DISTpre_i$ represents the Euclidean distance to the plant's address prior to production, $DISTpost_i$ represents the Euclidean distance to the operational plant's address, $DISTpost_i^2$ represents distance squared, $Time_{it}$ represents year indicator variables to capture the sale date of each house, and ε_i is the error term.

The objective of equation (1) is to provide a clear examination of whether neighboring properties experience adverse effects from the ethanol plant. To accomplish this, three particular variables in equation (1) are of interest: $preD_i$, $DISTpre_i$, and $DISTpost_i$. The coefficient for the first variable indicates whether or not the intercept differs between properties sold before and after the plant began production. The coefficients for the latter two variables provide a clear estimate of the ethanol plant's impact on property values as the distance between the plant and a given property increases. It is anticipated that the coefficient for $DISTpre_i$ will be statistically insignificant, providing evidence that there were no negative externalities at (or near) the location prior to the operational plant. The coefficient for $DISTpost_i$ is expected to be statistically significant and positive, indicating that the closer a house is to the plant, the lower its price. Finally, in addition to the three primary impact variables, the coefficient for $DISTpost_i^2$ will be included to measure non-linear effects of the ethanol plant. It is anticipated that the coefficient for $DISTpost_i^2$ will be negative, implying that there is a diminishing effect as the distance between the plant and the property increases.

In addition to the anticipated results of the two key distance variables ($DISTpre_i$ and $DISTpost_i$), including distance to the site prior to the operational plant is a unique feature of this study. The majority of previous hedonic work has focused on measuring the impact of an externality exclusively during the years the plant is operational. A potential downfall of excluding the distance prior to the facility's existence is attributing a negative effect to the facility when the true cause may be some unobserved factor that prevailed prior to the plant. Including properties and their distance to the site before the plant's operations allows for direct comparisons within the same community to ensure there was no unforeseen, pre-existing factor.

Although equation (1) is an adequate first approximation, the negative effect of the ethanol plant measured in equation (1) may be larger (i.e., more negative) for properties closer to the plant since the coefficient for $DISTpost_i$ captures the effect on all properties (including those miles away). With this consideration, a second regression will be used to further appraise the impact on properties closest to the plant. This model is represented by the following equation:

$$PRICE_i = \alpha + \sum_{j=1}^{m} \beta_j X_{ij} + \sum_{l=1}^{n} \gamma_l L_{il} + \delta_1 preD_i + \delta_2 DISTpre_i + \sum_{r=1}^{d} \rho_r RING_{ir} + \sum_{t=1}^{k} \theta_t TIME_{it} + \varepsilon_i \quad (2)$$

where $PRICE_i$, X_{ij}, L_{il}, $preD_i$, $DISTpre_i$, $Time_{it}$, and ε_i are the same as in equation (1). Rather than measure the Euclidean distance between the plant and each residential property, $Ring_{ir}$ measures incremental, half-mile rings around the ethanol plant. It is expected that relatively large negative impacts will be observed for the first few rings but the effects will dissipate as the distance increases.

3.3. Structural Attributes (X)

While the list of structural attributes that could be included is extensive, only those variables suggested in the literature as consistently having a significant impact on the value of residential properties are included. The structural characteristics collected include: size of the house, size of the lot, age of the house, number of bedrooms, number of bathrooms, number of stories, the existence of a basement, the existence of an attached garage, and the existence of central air conditioning (following the examples of Palmquist, 1984; Pollakowski, 1995; Brasington and Hite, 2005). It is expected that as most of these housing attributes increase (or are present as in the case of a garage, a basement, and central air), they will have a positive impact on the price of property. Three exceptions to this expectation are age of the house, number of bedrooms, and number of stories. While it is obvious that the age of the house will have a negative impact, the expected impact that the number of bedrooms and number of stories will have on the price is ambiguous. Once size is controlled for, additional rooms translate to smaller rooms. It is therefore unclear whether more small rooms are preferred to fewer large rooms. Similarly, an additional story translates into a more divided house. In their review, Sirmans et al. (2005) observed bedrooms to be positive in twenty-one out of forty studies including the variable and stories to be positive in only four out of thirteen studies. Some studies exclude the number of bedrooms or stories altogether, citing that they are not reliable due to collinearity when the size of the structure is included (McClelland, Schulze, and Hurd, 1990). The ethanol plant's effect remains the same whether or not bedrooms and stories are included.

In addition to including the linear measurements of each structural attribute, it may be beneficial to use the squares of the lot size, house size, and age of the house, since these are expected to influence the value of a house in a nonlinear fashion (Brasington and Hite, 2005). Nonlinearities are expected due to diminishing returns in consumption (Witte, Sumka, and Erekson, 1979).

3.4. Neighborhood attributes (L)

The list of potential neighborhood attributes is extensive. Focusing on the neighborhood variables that are most likely to have an impact, two key variables that are often cited are distance to the town center and an indicator variable equal to one if the property is located within the city limit and zero otherwise.[8] It is anticipated that each variable will be positive, as a town may offer a variety of amenities. As with distance to the ethanol plant, it may be beneficial to include the square of distance to the town center to measure diminishing effects.

3.5. Time

As stated above, the sale date of each house will be captured by a year indicator variable. Since prices used are in real terms (inflated to 2009 values), inclusion of the sale date captures the effect of general market trends over time (as well as other fixed effects). Although the effect of each year indicator variable depends on local housing market trends, a negative effect each year after 2006 is anticipated as the housing market collapsed nationwide.

3.6. Functional form

While hedonic price models have been used to routinely analyze the market price of multiple housing attributes, a common challenge for all hedonic studies is selecting the appropriate functional form (Cropper, Deck, and McConnell, 1988). Since theory provides no *a priori* guidance regarding functional form, it is common to empirically determine the functional form that best fits the data (Palmquist, Roka, and Vukina, 1997). Following previously cited literature, two functional forms, linear and semi-log (natural logarithm of the dependent variable), were considered. To determine which model best fit the data, each specification's sum of squared residuals were compared once the observed prices were normalized by their geometric means. Palmquist and Danielson (1989) show that this procedure is equivalent to the Box-Cox criterion.

Based on the sum of squared residuals, the two specifications are not statistically different from each other, so both the semi-log and linear results are presented in the appendices. Although the results of the two functional forms are similar, discussion of the results in Section 5 is based on the semi-log form. Historically, implementing the semi-log specification is preferred, and the semi-log regressions presented below are generally more conservative (Sirmans et al., 2005).

4. Data

4.1. Areas of study

Figure 2 presents a map detailing all operating ethanol plants in Michigan. Of the five operational plants, only two are examined in this study: POET Biorefining in Caro (operational October 2002) and Marysville Ethanol, LLC, in Marysville (operational September 2007). These locations were chosen for two key reasons: 1) both plants have operated for a significant period of time allowing for more pre- and post- plant operations sales data; and 2) both communities have had a substantial number of sales during the time period of interest.[9]

4.2. Data on house prices and desired attributes

To conduct the hedonic analysis described above, detailed information on the price, the structural attributes, and the neighborhood characteristics of houses surrounding the ethanol plants was assembled. Two Michigan multiple listing services (MLS) provided data: MiRealSource and RMLS.[10] All available sales data between 1999 and 2009 were collected for each community. A total of 1,956 home sales were obtained (909 from Caro and 1,046 from Marysville).

[8] Direction of the property from the plant was also considered, but Abeles-Allison and Connor (1990) have shown this to not be statistically significant in their study examining hog farms. Furthermore, there exist only a small number of observations downwind from the ethanol plant (see Figure 3), and inference based on only a few observations would be unreliable.

[9] Other plant locations are more rural, and a very limited number of sales were available for those communities since the plant went online (30 or less for each community). Inference drawn from regressions with a small number of observations would be unreliable.

[10] Both MiRealSource and RMLS are online member services.

Upon examining the data, two remaining issues required attention: 1) the neighborhood characteristics of each property still needed to be determined since multiple listing services do not provide these features; and 2) a large number of Caro properties required structural characteristics to be added as information was missing in both MLS databases. To handle the first issue, all included properties were geo-coded and mapped using a Geographic Information Systems (GIS) database. Mapping the sales resulted in 129 dropped observations (60 in Caro and 69 in Marysville), as the addresses were not in the GIS database. Furthermore, upon examination of the mapped properties, a large number of properties were apparently miscoded and were located large distances from the areas of interest (often appearing in cities or towns miles away). These observations were therefore excluded. The final number of mapped data included 824 sales in Caro and 887 sales in Marysville. Using these 1,712 sales, the neighborhood characteristics of interest were determined using the GIS database.

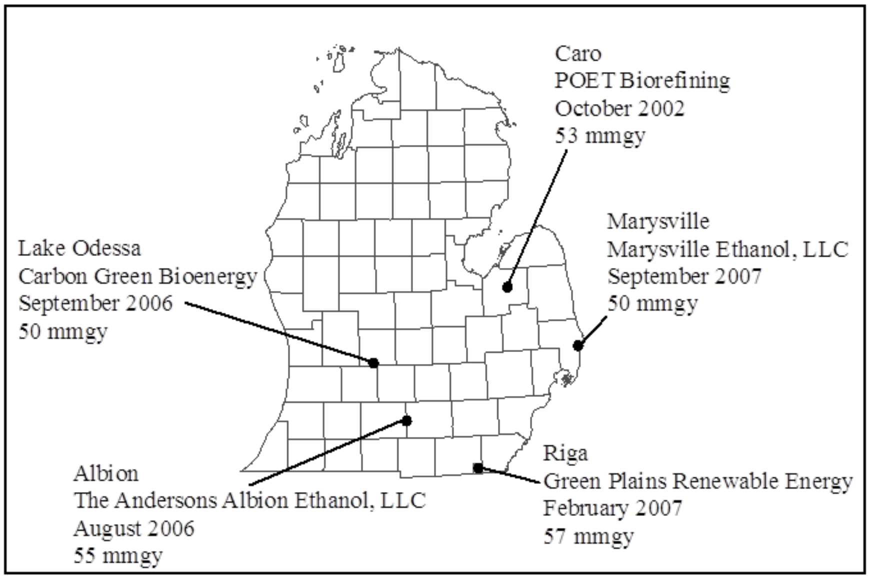

Figure 2. Michigan ethanol plants location, name, start date, and nameplate production capacity.

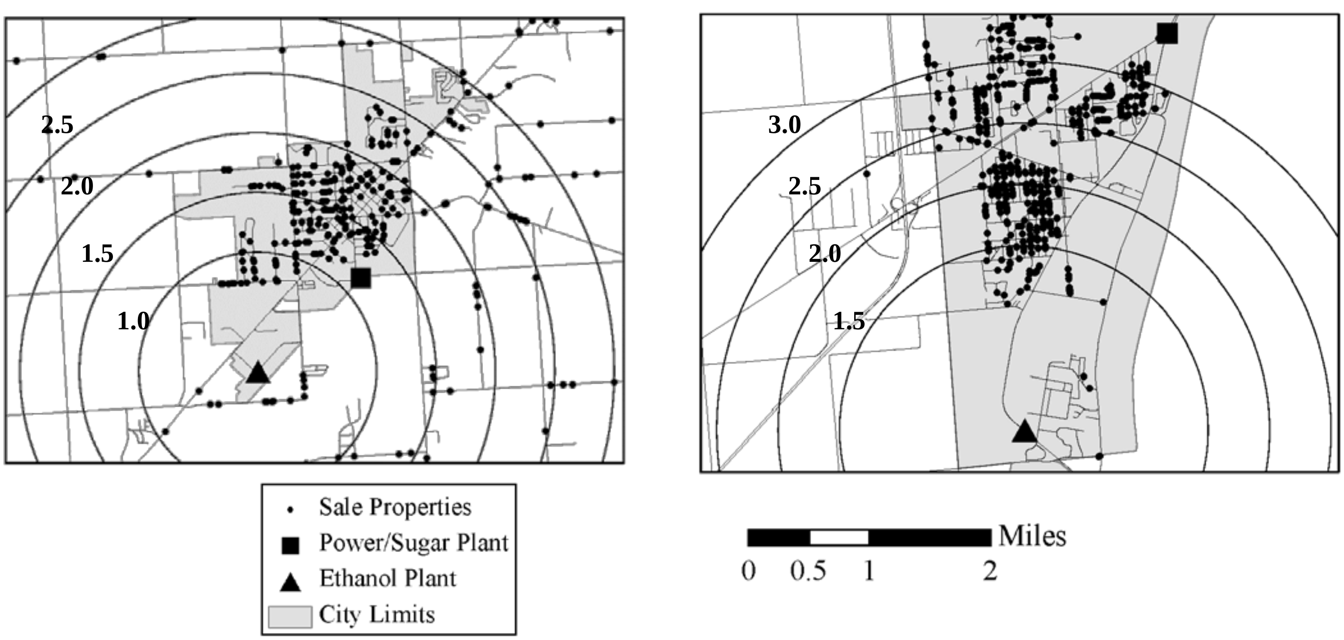

Figure 3. Location of select properties in Caro (left) and Marysville (right).

With the aid of the local assessor, the issue of missing structural data of Caro properties was resolved. Of the properties collected, the assessor was unable to locate the following: age for 123 properties, square footage for an additional three properties, and lot size for an additional 27 properties. Thus, the final Caro dataset that included all attributes totaled 671 sales.

4.3. Additional concerns

Beyond data completeness, there are three additional concerns with the dataset. The first issue stems from the rural nature of the data. As highlighted in Henderson and Gloy (2008), the effect of an ethanol plant on farmland property may be positive, resulting from increased demand for neighboring farmland commodities. Beyond the positive effect of the ethanol plant on farmland properties, it is reasonable to expect valuation differences to arise between residential and farmland properties as the latter are marketed and sold based primarily on their agricultural production capacities rather than their housing attributes. Therefore, to be sure that only residential properties are considered, all properties with more than ten acres have been excluded from the dataset. This restriction is a common practice for hedonic analyses of residential properties in rural communities (Abeles-Allison and Connor, 1990; Palmquist, Roka, and Vukina, 1997; Herriges, Secchi, and Babcock, 2005). An additional 43 observations were excluded in Caro, but none were excluded in Marysville.

The second concern stems from potential human error. In obtaining records from the MLS databases, there is no procedure to ensure the data reported are completely accurate. It is possible that some sales were mistyped and not enough zeros were included. This could result in biased estimates of the ethanol plant's impact, but only if the errors are somehow systematically related to the proximity of the home to the plant. Nevertheless, several homes are well below the typical price range. In particular, there were 19 transactions indicating a selling price of less than $20,000. Thus, I chose to exclude 17 observations for Caro and two observations for Marysville.[11] Although Herriges et al. (2005) expressed a concern that dropping such observations might exclude the properties most affected by the ethanol plant, this concern is outweighed by the potential for human error. Unreported regressions including these observations yield results that are similar to those presented in this paper.

The final concern relates to whether the omission of additional structural and neighborhood characteristics might lead to omitted variable bias, especially with regard to the coefficients of interest. Beyond the structural characteristics cited above, one additional structural characteristic in Marysville that requires attention is the fact that some residential units are condominiums. To handle this issue, an indicator variable equal to one if the unit is a condominium and zero if it is a house is included: a negative sign is expected (indicating condominiums sell for lower prices). Beyond the neighborhood characteristics cited above, there is one additional neighborhood characteristic in Caro and two characteristics in Marysville that should be included. Of particular concern in Caro is the potential effect of the sugar plant. The sugar plant is located within the city limits and may adversely affect properties, as the plant emits a pungent odor. To handle this, I include a variable that represents the Euclidean distance (and distance-squared) between the sugar plant's address and each residential property. Of particular concern in Marysville are the potential effects of the St. Clair River and the Detroit Edison power plant. An indicator variable representing those properties within one half-mile of the river will be included to estimate the impact of the river. It is anticipated that the river will have a positive effect on these properties. As with the sugar plant in Caro, the Euclidean distance (and distance-squared) from each property to the Detroit Edison power plant's address will be used to measure the effect of the power plant on neighboring properties. The impact of the power plant is anticipated to be negative (Blomquist, 1974).

Figure 3 (above) shows the location of a select number of collected properties within each community, as well as the location of the ethanol plants, sugar plant (Caro), and power plant (Marysville). Furthermore, the rings used in the analysis are represented with the distance (in miles) of each ring from the ethanol plant. The full list of variables and their definitions can be viewed in Table 1. Appendix 1 provides the summary statistics for Caro and Marysville.

[11] These transactions could also reflect family-to-family sales, in which socio-economic attachment influence selling price more than the physical attributes of the residence (Robison and Ritchie, 2010).

Table 1. Description of variables.

Variable	Description
REALPRICE	Sales price of the residential property (2009 dollars)
LivingArea	Size of the residential structure (square feet)
LotSize	Size of the property associated with the residential structure (acres)
Age	Age of the residential structure, estimated as continuous numbers with each number representing an additional decade.
Bedrooms	Number of bedrooms
Baths	Number of bathrooms
Stories	Number of stories
Basement	Indicator variable to distinguish whether the residential structure has a basement (1 = structure has a basement, and 0 otherwise)
Garage	Indicator variable to distinguish whether the residential structure has a garage (1 = structure has a garage, and 0 otherwise)
AC	Indicator variable to distinguish whether the residential structure has central air conditioning (1 = structure has central air, and 0 otherwise)
Condo	Indicator variable to distinguish whether the residential structure is a condominium (1 = structure is a cond, and 0 otherwise)
InTown	Indicator variable to distinguish whether the property is located within the city limits (1 = property within the limits, and 0 otherwise)
toTC	Distance to the town center, measured in miles (to the nearest hundredth)
RIVDum	Indicator variable to distinguish whether the property is located within a half mile from the St. Clair River (1 = property within this range, and 0 otherwise) [This variable only applies to Marysville properties.]
preD	Indicator variable to distinguish whether the property was sold prior to the start date of the ethanol plant (1 = property sold prior to the operational plant, and 0 otherwise)
DISTpre	Distance to the ethanol plant prior to production, measured in miles (to the nearest hundredth)
DISTpost	Distance to the operating ethanol plant, measured in miles (to the nearest hundredth)
toSugarPlant	Distance to the sugar plant, measured in miles (to the nearest hundredth) [This variable only applies to Caro properties.]
toPowerPlant	Distance to the power plant,measured in miles (to the nearest hundredth) [This variable only applies to Marysville properties.]

5. Results

Given that housing markets are highly localized and spatially segmented (Sirmans et al., 2005), regressions for the two locations are estimated separately to obtain the implicit marginal price for the housing attributes in each community. The results for Caro are presented in Appendix 2 and the results for Marysville are presented in Appendix 3. The results presented in columns (1) and (2) reflect equation (1), using $DISTpost_i$ to capture the effect of the ethanol plant on property values and $DISTpost_i^2$ to capture non-linear effects. To further examine the impact, and to better capture non-linearities, columns (3) and (4) present the non-linear effects of the ethanol plant in Caro using the approach reflected in equation (2). Furthermore, columns (1) and (3) of each table contain the results for the semi-log estimation and columns (2) and (4) contain the linear estimation results.

5.1. House characteristics: Caro

First, we consider the results for the standard variables included in the analysis. The structural variable coefficients have the correct signs, are statistically significant, and appear to be reasonable estimates when transformed to dollar values. Examining the variables concerning size of the house and size of the lot, the results indicate that an additional square foot of living space adds approximately $36 of value, on average, while an additional acre of land adds $7,800.[12] The impact of age on the house is the only negative effect among the structural characteristics, as expected. The results indicate that there is a decrease of approximately $530 for each additional year since construction of the house. Since the coefficients for *Basement*, *Garage*, and *AC* represent the impacts of dummy variables, one cannot simply multiply each by 100 to get the corresponding percent change (as is done for continuous variables). Following the procedure provided by Halvorsen and Palmquist (1980), the presence of a basement increases the value of the average house by $23,700 and the presence of an attached garage increases the average house price by approximately $22,450. The presence of central air conditioning also generates a large premium, increasing the value of the average house by $14,200. Finally, an additional full bathroom increases the value of the average house by approximately $8,600.[13]

As shown in Appendix 2, two structural characteristics that are not statistically significant are *Bedrooms* and *Stories*. This result is not surprising from a theoretical perspective as mulicollinearity is anticipated with the inclusion of *LivingArea*. This result is also not surprising from an empirical perspective as previous hedonic studies indicate statistical insignificance when the size of the house is included (Kashian, Eiswerth, and Skidmore, 2006; McClelland, Schulze, and Hurd, 1990).

Turning attention to the year indicator variables which capture market trends, the only years that are statistically different than the base year (1999) are 2002 and 2006-2009. Each coefficient is negative, and from 2006 to 2009 a larger negative impact is observed for each additional year. In 2006, house values decreased by 19.8% (or approximately $20,500) since 1999. By 2009, properties in the Caro community experienced large net decreases as a result of the recession, and the coefficient for 2009 indicates an estimated decline of approximately 49.5% in the average house sale since 1999! While this may seem drastic, Figure 4 highlights annual average house prices in the Caro area and supports this result.

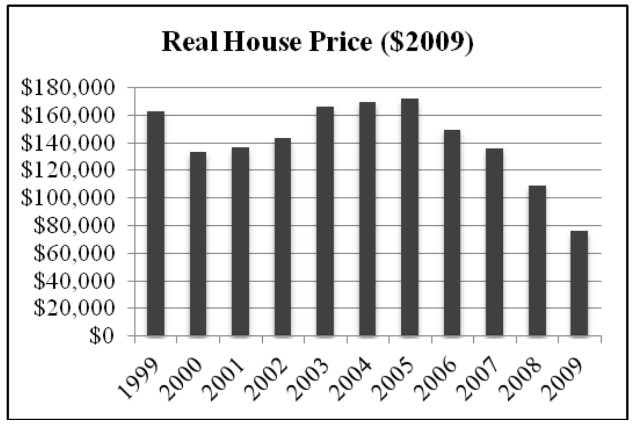

Figure 4. Average house prices for the Caro area (Michigan Association of Realtors)[14].

5.2. Neighborhood attributes: Caro

Examination of the included neighborhood characteristics validates the expectation of the ethanol plant's impact and provides insight concerning other neighborhood effects. As expected, being located within the city limits appears to have a positive effect on the house (although statistically insignificant). The coefficient for *preD* is statistically insignificant, indicating there is no change in the intercept between properties sold prior to plant operations. Unexpected is the statistically insignificant effect of distance from the town center. Another unanticipated result is the statistically insignificant effect of the sugar plant, indicating that it has no effect on the price of nearby residential properties.

Finally, the estimated effect of the ethanol plant is negative. This result should be considered in two parts. In column (1), the coefficient *DISTpre*

[12] Special attention must be given when interpreting coefficients including a squared term since the two coefficients may not simply be combined to get the estimated impact of each variable in percentage terms. Rather, the first derivative of the combined coefficients must be calculated.

[13] Although the estimates for garage, central air, and bathroom seem high, each is within the typical range cited by Sirmans et al. (2005). The presence of central air conditioning may also represent a proxy for updating a house. This would further support the large premium observed from central air conditioning.

[14] While the large (and seemingly significant) decline from 1999 to 2000 is not consistent with the regression results, the data collected for 1999 was from the Lapeer Association of REALTORS while the data for 2000-2009 was from the Lapeer and Upper Thumb Association of REALTORS (a group which includes Caro). Using the Lapeer Association of REALTORS for 1999 is the only way of consistently representing all years, since it is not apparent what group of realtors the Caro area had belonged to at that time (if any).

represents the distance to the location of the plant before the plant was online. This coefficient is statistically insignificant and verifies that there was no externality (positive or negative) at, or near, the site prior to plant production. The second coefficient, *DISTpost*, shows the negative impact of the plant once operations began. One interpretation of the combined effect of *DISTpost* and $DISTpost^2$ is that property values increase as their distance from the plant increases, but at a decreasing rate. The average property experienced an increase in value of approximately 3.4% for each mile from the plant. In terms of dollar values, this translates into an increase of $3,600 per mile. While this effect is as expected, distance from the plant varies greatly (from two-tenths of a mile to ten miles). Since *DISTpost* measures the average impact of all houses within this range, the estimated impact of the plant on the closest properties may be underestimated.

To more completely examine the effect of the ethanol plant on houses closer to the plant and to examine nonlinear effects with easier interpretation, several rings representing interval distances from the plant have been used in the alternative specification of the regression. *Ring1* represents all properties within one mile from the plant, *Ring1.5* represents properties between 1-1.5 miles, *Ring2* represents properties between 1.5-2 miles, *Ring2.5* represents properties between 2-2.5 miles, and *Ring3* represents properties between 2.5-3 miles. All other properties outside these rings serve as the baseline since the effect is not anticipated to reach farther than three miles. Note, however, that *Ring1* includes all properties within one mile while the others are measured in half-mile increments. The first ring extends to one mile because there are a small number of observations within the first half-mile, and imprecise estimates would likely result due to the small number of observations. Interpreting the results in columns 3 and 4 of Appendix 2, the ethanol plant has a negative effect on properties as far as two miles away. As anticipated, those properties closer to the plant experience a larger negative effect than was measured in the Euclidean distance regression. Interpreting the results, those within two miles sold for 15-18% less after the plant began operations.

5.3. House characteristics: Marysville

Examining the Marysville estimates and comparing them with Caro confirms that tastes and preferences differ among consumers, as the price consumers are willing to pay for a given bundle of attributes (or even a single attribute) differ. The most striking differences are those that change statistical significance: *LotSize* is no longer significant; *Bedrooms* and *Stories* are no longer insignificant; *InTown* is significant and negative; *toTC* is significant and positive; and the ethanol plant has no impact.

Examining the structural characteristics, most have the anticipated sign, are statistically significant, and appear to be reasonable estimates when transformed to dollar values. The coefficient for *LivingArea* indicates that an additional square foot of living space adds approximately $54 of value, on average. For each year older the house becomes, the value decreases by approximately $430. The presence of a basement generates a smaller premium than was estimated in Caro, increasing the value of the average house by $18,400, while the presence of an attached garage generates a larger premium than was estimated in Caro, increasing the value of the house by $29,000. Having central air conditioning also generates a slightly larger premium in Marysville, increasing the value of the average house by $15,600. Finally, an additional full bathroom increases the value of the average house by approximately $14,000.[15]

As mentioned, *Bedrooms* and *Stories* are statistically significant. An additional bedroom increases the value of the average house by $4,400 and an additional story decreases the value by $11,700. Finally, the indicator representing condominiums shows that the average condo sells for approximately $21,500 less than the average house (*ceteris paribus*).

Examining the year indicator variables highlights that the first seven years are statistically no different than the base year (1999) and the coefficients for 2007-2009 are each statistically significant and negative. Comparing these results with Caro, the Marysville housing market appears to have experienced a smaller negative impact in 2007 and 2008; however, by 2009 the Marysville market was in the same situation as Caro, with the average house sale approximately 47% less than in 1999. As before, this is not an unreasonable estimate as Figure 5 shows the yearly trends in the Marysville housing market.

5.4. Neighborhood attributes: Marysville

The results of the included neighborhood variables are surprising. The variables representing in town, distance to town, distance to the river, and

[15] Again, the estimates are within the ranges presented by Sirmans et al. (2005).

distance to the power plant are statistically significant and have signs opposite of what was anticipated. Being located in town (*InTown*) has a large negative effect, and being located farther from the center of town (*toTC*) appears beneficial. However, once the squared term for *toTC* is included the effect validates expectations: the average house decreases approximately 2.8% for each additional mile from the town center.

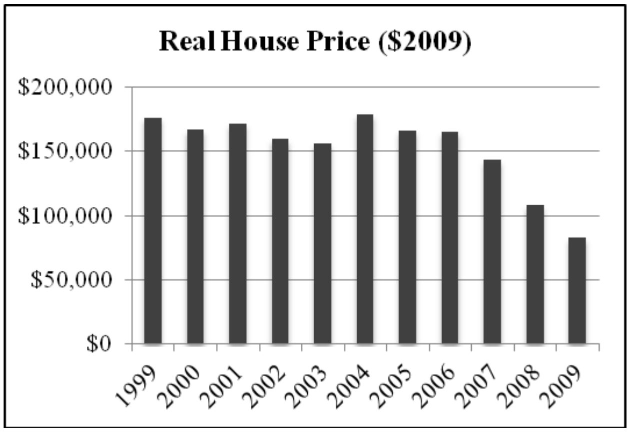

Figure 5. Average house prices for the Marysville area (Michigan Association of Realtors).

The coefficient for *River*, indicating a property is within one-half mile of the River, is negative. Observing a negative effect from the river seems counterintuitive; however, the negative effect may be the result of a large number of properties within a half-mile not having access to or a view of the river while being in the floodplain (requiring a discount due to higher insurance). To examine this issue further, five new variables have been created: *River1* representing properties within 0.1 miles of the river, *River2* representing properties within 0.1-0.2 miles of the river, *River3* representing properties within 0.2-0.3 miles of the river, *River4* representing properties within 0.3-0.4 miles of the river, and *River5* representing properties within 0.4-0.5 miles of the river. The summary statistics for these variables are shown in Table 2, and Table 3 shows the coefficients of each new variable by including them into the regressions from Appendix 3. As the results show, the river has the anticipated positive effect on the closest properties.

As with the sugar plant in Caro, the distance to the power plant has the opposite sign of what was anticipated. Unlike the sugar plant in Caro, it is statistically significant; however, the effect is minimal, as the average property value decreases by approximately 0.7% percent for each mile from the plant.

Table 2. St Clair River summary statistics.

Variable	Mean	Std Dev	Min	Max
River1	0.030	0.172	0	1
River2	0.024	0.152	0	1
River3	0.042	0.200	0	1
River4	0.089	0.285	0	1
River5	0.023	0.149	0	1
# of Obs.	885			

Table 3. The effect of the St Clair River

Independent Variables	Dependent Variable Ln(RealPrice)
River1	0.1446*** (0.0527)
River2	0.2810*** (0.0760)
River3	-0.1141** (0.0508)
River4	-0.0515* (0.0312)
River5	-0.1023*** (0.0371)

Finally, the estimated effect of the ethanol plant is statistically insignificant. To ensure that these results are robust and that the conclusion is not a result of downward bias from the furthest properties, the several rings representing interval distances from the plant were used in the alternative regressions. One key difference exists between the rings created for Marysville and Caro: the first ring for Marysville (*Ring1.5* in Appendix 3) extends to 1.5 miles from the plant. This was done because there are a small number of observations within the first mile of the plant, and imprecise estimates would likely result due to the small number of observations. Beyond *Ring1.5,* the remaining rings mirror those created for Caro. Again, all properties farther than three miles serve as the baseline because the effect is not anticipated to reach farther than three miles. Examining the regressions in Column 3 of Appendix 3, the coefficient representing all properties within 1.5 miles of the plant is statistically insignificant. This provides additional evidence that properties closest to the ethanol plant have not experienced any depreciation in value from the ethanol plant. Finally, it is worth noting that *Ring2* and *Ring2.5* are positive and highly significant, perhaps indicating some positive externality that has not been considered.

To provide insight into why there was no measurable impact on neighboring property values in Marysville when Caro was clearly affected, three hypotheses are considered. The first hypothesis relates to data issues. Although a sufficient number of observations have been accumulated to present satisfactory hedonic results, there are very few properties within a one-mile radius of the plant (less than one percent of all observations) in Marysville. Although the impact was felt up to two miles in Caro and the number of properties within two miles in Marysville is significant (approximately 34% of all observations), there is no reason to expect the impact in Marysville to reach the same distance as was experienced Caro. Therefore, the few observations within one mile of the Marysville ethanol plant may not have been enough to observe an adverse effect. The second hypothesis centers on visibility. Trees in the Marysville community are abundant. Perhaps the adage "out of sight, out of mind" applies to the Marysville ethanol plant. That is, visibility may be a requirement for some ethanol plants to adversely impact the surrounding community. The third hypothesis stems from pre-existing conditions at the plant's location. The Marysville ethanol plant was placed in an already developed industrial area, whereas Caro did not have pre-existing industrial facilities. Perhaps failure to observe an impact stems from the plant not adding any additional perceived negative externality. All three of the explanations are reasonable; unfortunately, the data are not suitable to determine which is the best explanation.

6. Conclusion

This study contributes to the existing literature in three ways. First, an in-depth analysis concerning the impact of an ethanol plant on residential properties has been provided. Two communities with ethanol plants were examined in this study to determine whether ethanol plants have adverse effects on nearby property values. Each community examined offers a different landscape and is in many ways representative of ethanol plant communities across the country. Marysville is a larger community with more industry, whereas Caro is a smaller farming community with little pre-existing industry. As highlighted, the location of an ethanol plant may adversely affect neighboring property values, depressing the value of homes as much as 18% and as far as two miles away. However, this conclusion may not be universal, as consumer tastes and preferences differ across space and time. In addition, conditions surrounding residential properties, including inability to see the plant and pre-existing industry, may limit the impact of an ethanol plant.

These findings have practical significance for community planners considering whether to allow an ethanol plant to locate in their community and how to determine a suitable location. These results suggest that community planners should direct ethanol plants to be built in areas where they are not seen or are among pre-existing industrial buildings to minimize the impact. However, this is not always possible as the ethanol industry is filling the landscape of rural America, where vegetation (other than fields) and pre-existing industry are minimal.

The second contribution of this study is a potential upper limit on the effect of ethanol plants on residential property values that should be added to future cost-benefit studies examining the ethanol industry. Although the current study has highlighted the impacts of this cost on property owners, future cost-benefit studies may need to also include this cost in terms of property taxes. If property values are decreasing, homeowners and the community may experience negative effects as both property values and property taxes decline.

Finally, this study contributes to the general research implementing the hedonic method by illustrating a technique to evaluate negative externality impacts in a way that allows within community comparisons before and after a plant begins production. Using this approach helps to assure researchers, decision makers, and others that any observed negative impact is not the result of pre-existing conditions in the community.

References

Abeles-Allison, Mark, and Larry J. Connor. 1990. An Analysis of Local Benefits and Costs of Michigan Hog Operations Experiencing Environmental Conflicts. *Michigan State University Extension*. June 1990.

Barrionuevo, Alexei. 2006. Boom in Ethanol Reshapes Economy of Heartland. *The New York Times*. 25 June 2006.

Blomendahl, Ben, and Bruce Johnson. 2009. Has the Ethanol Industry Impacted Nebraska Land Values? *Cornhusker Economics* 8 April 2009.

Blomquist, Glenn. 1974. The Effect of Electric Utility Power Plant Location on Area Property Value. *Land Economics* 50.1: 97-100.

Brasington, David M., and Diane Hite. 2005. Demand for Environmental Quality: A Spatial Hedonic Analysis. *Regional Science and Urban Economics* 35.1: 57-82.

Court, A. T. 1939. Hedonic Price Indexes with Automotive Examples, *Dynamics of Automoblie Demand*, New York, NY: General Motors.

Cropper, Maureen L., Leland B. Deck, and Kenneth E. McConnell. 1988. On the Choice of Functional Form for Hedonic Price Functions. *The Review of Economics and Statistics* 70.4: 668-75.

Cotti, Chad, and Mark Skidmore. 2010. The Impact of State Government Subsidies and Tax Credits in an Emerging Industry: Ethanol Production 1980–2007. *Southern Economic Journal* 76.4: 1076-93.

Gardner, Bruce. 2007. Fuel Ethanol Subsidies and Farm Price Support. *Journal of Agricultural and Food Industrial Organization* 5.2.

Goodman, Allen C. 1978. Hedonic Prices, Price Indices and Housing Markets. *Journal of Urban Economics* 5: 471-84.

Haas, G. C. 1922. A Statistical Analysis of Farm Sales in Blue Earth County, Minnesota, as a Basis for Farm Land Appraisal, Masters Thesis, the University of Minnesota.

Hahn, Robert, and Caroline Cecot. 2009. The Benefits and Costs of Ethanol: An Evaluation of the Government's Analysis. *Journal of Regulatory Economics* 35.3: 275-95.

Halvorsen, Robert, and Raymond Palmquist. 1980. The Interpretation of Dummy Variables in Semilogarithmic Equations. *The American Economic Review* 70.3: 474-75.

Harrison, Jr, David, and Daniel L. Rubinfeld. 1978. Hedonic Housing Prices and the Demand for Clean Air. *Journal of Environmental Economics and Management* 5: 81-102.

Henderson, J., and B. A. Gloy. 2008. The Impact of Ethanol Plants on Cropland Values in the Great Plains. Regional Research Working Paper, Federal Reserve Bank of Kansas City.

Herriges, Joseph A., Silvia Secchi, and Bruce A. Babcock. 2005. Living with Hogs in Iowa: The Impact of Livestock Facilities on Rural Residential Property Values. *Land Economics* 81.4: 530-45.

Hoyer, Meghan, and Mike Saewitz. 2007. Study Denounces Project's Impact. *The Virginian-Pilot* 20 Nov. 2007.

Kashian, Russ, Mark E. Eiswerth, and Mark Skidmore. 2006. Lake Rehabilitation and the Value of Shoreline Real Estate: Evidence from Delevan, Wisconsin. *The Review of Regional Studies* 36.2 : 221-38.

Kiel, Katherine A., and Katherine T. McClain. 1995. House Prices During Siting Decision Stages: The Case of an Incinerator From Rumor Through Operation. *Journal of Environmental Economics and Management* 28: 241-55.

McClelland, Gary H., William D. Schulze, and Brian Hurd. 1990. The Effect of Risk Beliefs on Property Values: A Case Study of a Hazardous Waste Site. *Risk Analysis* 10: 485-97.

McMillen, Daniel P., and Paul Thorsnes. 2003. The Aroma of Tacoma: Time-Varying Average Derivatives and the Effect of a Superfund Site on House Prices. *Journal of Business and Economic Statistics* 21.2: 237-46.

McNew, Kevin, and Duane Griffith. 2005. Measuring the Impact of Ethanol Plants on Local Grain Prices. *Review of Agricultural Economics* 27.2: 164-80.

Meersman, Tom. 2001. Ethanol plants pose pollution challenge. *Star Tribune* 8 July 2001 *[Minneapolis-St. Paul]*.

Nelson, Jon P. 1978. Residential Choice, Hedonic Prices, and the Demand for Urban Air Quality. *Journal of Urban Economics* 5.3: 357-69.

Niven, Robert K. 2005. Ethanol in Gasoline: Environmental Impacts and Sustainability Review Article. *Renewable and Sustainable Energy Reviews* 9.6: 535-55.

Palmquist, Raymond B. 1984. Estimating the Demand for the Characteristics of Housing. *The Review of Economics and Statistics* 66.3: 394-404.

Palmquist, Raymond B., and Leon E. Danielson. 1989. A Hedonic Study of the Effects of Erosion Control and Drainage on Farmland Values. *American Journal of Agricultural Economics* 71: 55-62.

Palmquist, Raymond B., Fritz M. Roka, and Tomislav Vukina. 1997. Hog Operations, Environmental Effect, and Residential Property Values. *Land Economics* 73.1: 114-24.

Pimentel, David. 1991. Ethanol Fuels: Energy Security, Economics, and the Environment. *Journal of Agricultural and Environmental Ethics* 4.1: 1-13.

Pimentel, David. 2003. Ethanol Fuels: Energy Balance, Economics, and Environmental Impacts Are Negative. *Natural Resources Research* 12.2: 127-34.

Pollakowski, H. O. 1995. Data Sources for Measuring Housing Price Changes. *Journal of Housing Research* 6.3: 377-87.
Ridker, Ronald G., and John A. Henning. 1967. The Determinants of Residential Property Values with Special Reference to Air Pollution. *Journal of Political Economy* 82: 34-55.
Robison, Lindon J., and Bryan K. Ritchie. 2010. *Relationship economics: the social capital paradigm and its application to business, politics and other transactions*. Farnham, Surrey, UK.: Gower.
Rosen, Sherwin. 1974. Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. *Journal of Political Economy* 82.1: 34-55.
Runge, C. Ford, and Benjamin Senauer. 2007. How Biofuels Could Starve the Poor. *Foreign Affairs* 86.3: 41-53.
Saphores, Jean-Daniel, and Ismael Aguilar-Benitez. 2005. Smelly Local Polluters and Residential Property Values: A Hedonic Analysis of Four Orange County (California) Cities. *Estudios Economicos* 20.2: 197-218.
Searchinger, T. , R. Heimlich, R.A. Houghton, F. Dong, A. Elobeid, J. Fabiosa, S. Tokgoz, D. Hayes, and T. Yu. 2008. Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land-Use Change. *Science* 319: 1238-1240.
Sirmans, G. Stacy, David A. Macpherson, and Emily N. Zietz. 2005. The Composition of Hedonic Pricing Models. *Journal of Real Estate Literature* 13.1: 1-44.
Smolen, Gerald E., Gary Moore, and Lawrence V. Conway. 1992. Economic Effects of Hazardous Chemical and Proposed Radioactive Waste Landfills on Surrounding Real Estate Values. *Journal of Real Estate Research* 7.3: 283-95.
Turnquist, Alan, T. Randall Fortenbery, and Jeremy Foltz. 2008. Progress or Devastation? The Effects of Ethanol Plant Location on Local Land Use, 2008 Annual Meeting, July 27-29, Orlando, Florida, American Agricultural Economics Association.
Urbanchuk, John M. 2010. Contribution of the Ethanol Industry to the Economy of the United States. *Renewable Fuels Association,* Washington, D.C., 12 Feb. 2010.
Wallace, Henry A. 1926. Comparative Farm-Land Values in Iowa. *Journal of Land and Public Utility Economics* 2: 92-385.
Witte, Ann D., Howard J. Sumka, and Homer Erekson. 1979. An Estimate of a Structural Hedonic Price Model of the Housing Market: An Application of Rosen's Theory of Implicit Markets. *Econometrica* 47.5: 1151-73.
Zabel, Jeffrey E., and Katherine A. Kiel. 2000. Estimating the Demand for Air Quality in Four U.S. Cities. *Land Economics* 76.2: 174-94.

APPENDIX 1. Summary statistics.

	Caro				**Marysville**			
Variable	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max
REALPRICE	103,380	47,888	20,000	414,496	152,125	58,938	20,000	451,167
LivingArea	1440	533	540	5000	1380	459	550	4492
LotSize	1.49	2.10	0.07	10	0.25	0.23	0	3.86
Age	4.68	2.99	0	15	3.39	2.36	0	10
Bedrooms	2.99	0.77	1	6	2.94	0.66	1	6
Baths	1.60	0.59	1	4	1.79	0.68	1	4
Stories	1.26	0.40	1	3	1.31	0.42	1	2.5
Basement	0.71	-	0	1	0.78	-	0	1
Garage	0.75	-	0	1	0.87	-	0	1
AC	0.33	-	0	1	0.55	-	0	1
Condo	-	-	-	-	0.12	-	0	1
InTown	0.52	-	0	1	0.98	-	0	1
toTC	2.06	2.14	0	10.1	0.88	0.63	0.06	4.85
RIVDum	-	-	-	-	0.20	0.40	0	1
preD	0.22	0.42	0	1	0.82	0.38	0	1
DISTpre	3.00	2.16	0.76	10.85	2.43	0.82	0.63	5.56
DISTpost	2.73	1.85	0.26	10.85	2.48	0.87	0.63	5.56
Ring1	0.09	-	0	1	0.01	-	0	1
Ring1.5	0.18	-	0	1	0.14	-	0	1
Ring2	0.26	-	0	1	0.20	-	0	1
Ring2.5	0.08	-	0	1	0.14	-	0	1
Ring3	0.05	-	0	1	0.29	-	0	1
*To(Other)Plant**	2.21	2.02	0.2	10	1.55	0.78	0	5.53
2000	0.01	-	0	1	0.03	-	0	1
2001	0.11	-	0	1	0.13	-	0	1
2002	0.11	-	0	1	0.12	-	0	1
2003	0.12	-	0	1	0.14	-	0	1
2004	0.11	-	0	1	0.09	-	0	1
2005	0.15	-	0	1	0.13	-	0	1
2006	0.13	-	0	1	0.11	-	0	1
2007	0.11	-	0	1	0.09	-	0	1
2008	0.09	-	0	1	0.08	-	0	1
2009	0.05	-	0	1	0.06	-	0	1
# of Obs.	611				885			

*to(Other)Plant represents distance to the sugar plant in Caro and distance to the power plant in Marysville

APPENDIX 2. Caro regression results.

Independent Variables	Dependent Variable			
	Ln(RealPrice)	RealPrice	Ln(RealPrice)	RealPrice
Intercept	10.468*** (0.1678)	23187 (17812)	10.758*** (0.1927)	59136*** (20658)
LivingArea	0.0006*** (0.0001)	42.390*** (10.986)	0.0006*** (0.0001)	43.845*** (10.917)
LivingArea^2	-8.78e-08*** (2.03e-08)	-0.0019 (0.0031)	-8.58e-08*** (1.99e-08)	-0.0021 (0.0031)
LotSize	0.0918*** (0.0244)	9524.7*** (2608.6)	0.0945*** (0.0243)	9586.5*** (2592.1)
LotSize^2	-0.0056** (0.0025)	-552.86** (278.18)	-0.0058** (0.0025)	-564.04** (273.82)
Age	-0.0767*** (0.0152)	-8951.1*** (1461.5)	-0.0747*** (0.0154)	-8859.1*** (1503.0)
Age^2	0.0027** (0.0011)	370.69*** (107.38)	0.0027** (0.0011)	372.70*** (111.21)
Bedrooms	0.0285 (0.0247)	1619.8 (2204.9)	0.0276 (0.0246)	1142.90 (2208.5)
Baths	0.0834** (0.0334)	9063.2*** (2948.8)	0.0853** (0.0335)	9404.8*** (2975.4)
Stories	-0.0026 (0.0407)	-2769.3 (4335.9)	-0.0056 (0.0412)	-3148.5 (4457.8)
Basement	0.2061*** (0.0326)	21387*** (2868.4)	0.2090*** (0.0326)	21626*** (2873.8)
Garage	0.1965*** (0.0312)	16320*** (2514.3)	0.1968*** (0.0311)	16455*** (2525.1)
AC	0.1288*** (0.0265)	13189*** (2455.8)	0.1247*** (0.0270)	12679*** (2473.8)
InTown	0.0136 (0.0523)	-599.28 (5705.3)	0.0363 (0.0550)	5058.1 (5611.7)
toTC	-0.1157 (0.0909)	1353.0 (8130.1)	-0.0957 (0.1111)	10621 (10389)
toTC^2	0.0169 (0.0125)	161.14 (1052.8)	0.0165 (0.0134)	-818.31 (1218.7)
preD	0.0982 (0.0925)	15207* (9020.3)	0.0121 (0.0773)	1926.7 (7046.8)
DISTpre	0.0244 (0.0280)	4726.5 (2907.0)	0.0120 (0.0135)	1613.4 (1304.1)
DISTpost	0.0738* (0.0392)	12126*** (3826.6)	-	-
DISTpost^2	-0.0072 (0.0048)	-1062.2** (445.02)	-	-

APPENDIX 2. (cont'd)

Independent Variables	Dependent Variable			
	Ln(RealPrice)	RealPrice	Ln(RealPrice)	RealPrice
Ring1	-	-	-0.1776** (0.0920)	-28152*** (8376.4)
Ring1.5	-	-	-0.1971** (0.0914)	-24195*** (8246.5)
Ring2	-	-	-0.1637** (0.0738)	-16750** (7174.2)
Ring2.5	-	-	-0.0446 (0.0650)	-8517.8 (6073.0)
Ring3	-	-	-0.0910 (0.0726)	-4970.2 (7443.5)
toSugarPlant	0.0661 (0.0964)	-12695 (9583.7)	0.0134 (0.1244)	-23022* (12340)
$toSugarPlant^2$	-0.0126 (0.0132)	741.05 (1187.1)	-0.0099 (0.01379)	1844.0 (1321.1)
2000	-0.0976 (0.0856)	-13703* (8166.0)	-0.0920 (0.0876)	-10968 (8066.2)
2001	-0.0794 (0.0753)	-1230.3 (7998.9)	-0.1170 (0.0733)	-4987.0 (7607.6)
2002	-0.1346* (0.0788)	-4629.2 (8309.9)	-0.1646** (0.0765)	-7819.3 (7933.9)
2003	-0.1237 (0.1017)	-1445.2 (9932.8)	-0.1541 (0.1044)	-4516.3 (9776.3)
2004	-0.0158 (0.1011)	11222 (10119)	-0.0526 (0.1024)	6785.5 (9889.8)
2005	-0.0978 (0.1001)	-3372.9 (9827.9)	-0.1294 (0.1023)	-6353.2 (9672.6)
2006	-0.2212** (0.1002)	-10329 (9922.9)	-0.2520** (0.1024)	-13849 (9721.9)
2007	-0.4019*** (0.1042)	-26667*** (10199)	-0.4283*** (0.1070)	-29582*** (10132)
2008	-0.5156*** (0.1112)	-34202*** (10397)	-0.5391*** (0.1130)	-37168*** (10168)
2009	-0.6839*** (0.1245)	-50396*** (10897)	-0.7259*** (0.1236)	-54734*** (10740)
R-squared	0.6679	0.7028	0.6703	0.7036
# of Obs.	611			

Notes: All regression results are corrected for heteroskedasticity.
Asterisks denote significance at the 1% (***), 5% (**), and 10% (*) levels.

APPENDIX 3. Marysville regression results.

Independent Variables	Dependent Variable			
	Ln(RealPrice)	RealPrice	Ln(RealPrice)	RealPrice
Intercept	11.098*** (0.2104)	111190*** (20034)	11.003*** (0.1426)	103185*** (16218)
LivingArea	0.0005*** (0.0001)	26.084** (10.969)	0.0005*** (0.0001)	26.124** (10.644)
LivingArea^2	-5.18e-08*** (1.69e-08)	0.0101*** (0.0031)	-5.43e-08*** (1.69e-08)	0.0099*** (0.0031)
LotSize	0.0454 (0.0591)	5230.0 (8346.0)	0.0988 (0.0617)	13631 (8497.4)
LotSize^2	-0.0294* (0.0160)	-4660.2** (2358.4)	-0.0401** (0.0165)	-6754.7*** (2418.1)
Age	-0.0417*** (0.0103)	-7815.2*** (1496.0)	-0.0416*** (0.0100)	-8495.9*** (1430.2)
Age^2	0.0020 (0.0013)	534.25*** (174.84)	0.0016 (0.0013)	535.15*** (172.84)
Bedrooms	0.0291* (0.0157)	714.79 (2316.4)	0.0318** (0.0152)	-189.95 (2244.0)
Baths	0.0921*** (0.0146)	14631*** (2303.7)	0.0978*** (0.0147)	14219*** (2316.9)
Stories	-0.0767*** (0.0204)	-8758.1*** (2768.4)	-0.0692*** (0.0202)	-8656.7*** (2753.7)
Basement	0.1142*** (0.0198)	13070*** (2255.9)	0.1118*** (0.0194)	13446*** (2224.0)
Garage	0.1741*** (0.0248)	19205*** (2880.1)	0.1728*** (0.0239)	18337*** (2779.2)
AC	0.0976*** (0.0140)	11140*** (1879.1)	0.0946*** (0.0139)	11252*** (1869.4)
Condo	-0.1526*** (0.0326)	-22411*** (4708.9)	-0.1365*** (0.0318)	-20444*** (4708.7)
InTown	-0.1378* (0.0707)	-15821* (8146.4)	-0.1668** (0.0729)	-21346** (8596.4)
toTC	0.0971** (0.0475)	24540*** (7758.6)	0.2710*** (0.0652)	29352*** (10503)
toTC^2	-0.0669** (0.0336)	-13972*** (4481.3)	-0.1157*** (0.0334)	-18979*** (4713.2)
River	-0.1017*** (0.0309)	-9546.4** (4258.4)	-0.0883*** (0.0297)	-6961.7* (4062.5)
preD	0.1845 (0.1700)	9310.5 (12102)	0.0861 (0.0954)	-8104.8 (8277.1)
DISTpre	0.0176 (0.0344)	3949.5 (4070.2)	0.0381 (0.0323)	10413*** (2545.6)

APPENDIX 3. (cont'd)

Independent Variables	Dependent Variable			
	Ln(RealPrice)	RealPrice	Ln(RealPrice)	RealPrice
DISTpost	0.0599 (0.1270)	-8169.9 (8963.2)	-	-
DISTpost^2	-0.0160 (0.0236)	411.82 (1436.9)	-	-
Ring1.5	-	-	0.0315 (0.0655)	2315.7 (7800.9)
Ring2	-	-	0.1662*** (0.0584)	8756.5 (7883.5)
Ring2.5	-	-	0.1387*** (0.0499)	1399.7 (7091.7)
Ring3	-	-	0.0475 (0.0329)	-5975.3 (4240.3)
toPowerPlant	-0.2188*** (0.0701)	-41448*** (11844)	-0.2894*** (0.0752)	-50413*** (13548)
toPowerPlant^2	0.0681*** (0.0263)	13396*** (3766.0)	0.0901*** (0.0271)	17177*** (4087.5)
2000	0.0518 (0.0505)	13518* (7616.9)	0.0568 (0.0476)	13513* (7471.1)
2001	0.0120 (0.0439)	7679.8 (6164.6)	0.0157 (0.0401)	7035.7 (5975.1)
2002	-0.00004 (0.0434)	5901.7 (6080.6)	0.0055 (0.0397)	6251.7 (5898.4)
2003	-0.0207 (0.0434)	2969.3 (6032.7)	-0.0076 (0.0395)	2465.1 (5854.8)
2004	-0.0140 (0.0435)	3430.9 (6092.9)	-0.0058 (0.0398)	2548.0 (5914.2)
2005	-0.0095 (0.0429)	4947.2 (6118.0)	0.0012 (0.0391)	4884.8 (5955.6)
2006	-0.0354 (0.0440)	-918.19 (6408.2)	-0.0303 (0.0402)	-1622.8 (6241.6)
2007	-0.1190** (0.0491)	-10844 (7554.2)	-0.1134** (0.0448)	-11397 (7249.9)
2008	-0.2706*** (0.0785)	-32619*** (9342.9)	-0.2586*** (0.0758)	-32988*** (9150.5)
2009	-0.6334*** (0.0879)	-61327*** (9495.6)	-0.6463*** (0.0856)	-62431*** (9250.2)
R-squared	0.8182	0.8250	0.8229	0.8286
# of Obs.	885			