THE EFFECT OF ETHANOL PLANTS ON RESIDENTIAL PROPERTY VALUES: EVIDENCE FROM MICHIGAN

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ABSTRACT

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Since the mid 1990s, bio-fuel producers have built more than 130 ethanol plants across the United States, the majority of which have been placed in the upper Midwest. 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. Use of sales data over this ten-year period provides a unique analysis as it enables a comparison of properties pre- and post- plants coming on line. Furthermore, use of pre- and post-plant sales data provides greater confidence that any observed negative effect is truly the result of the ethanol plant and not some pre-existing, unobserved factor. 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.

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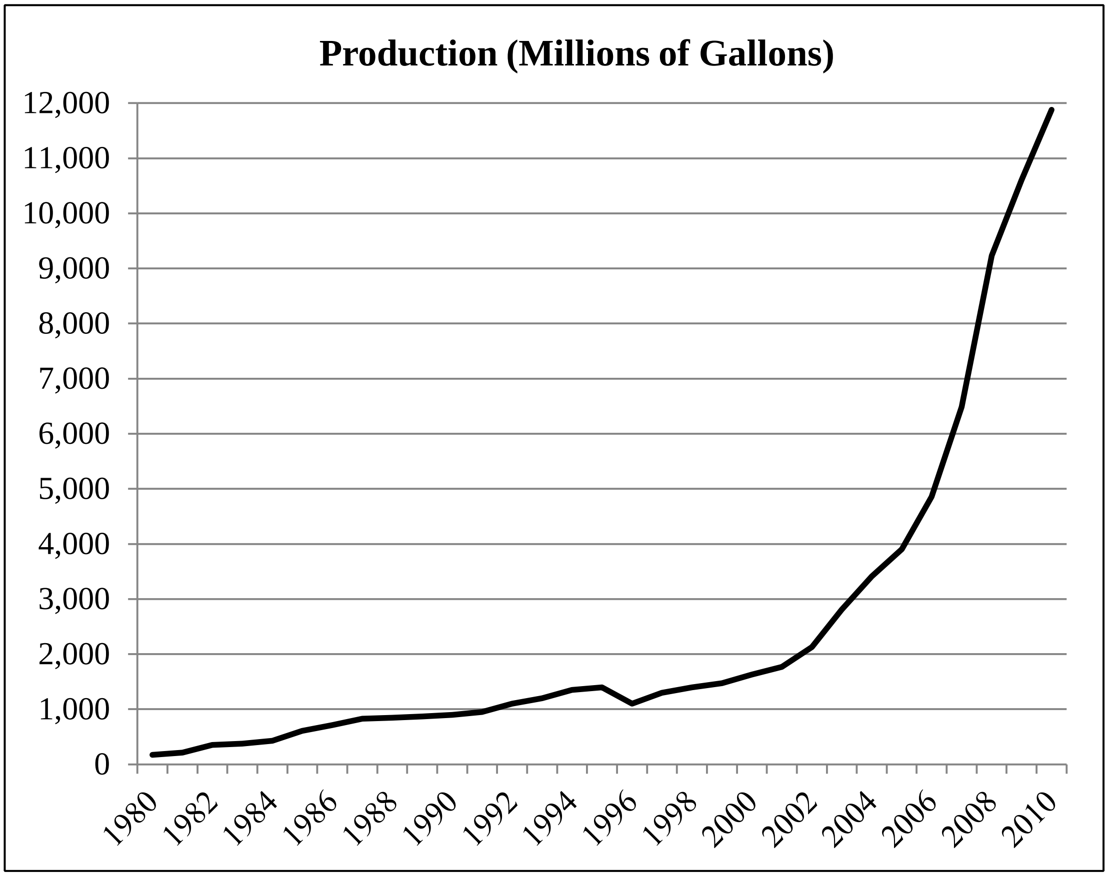
1. INTRODUCTION

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 ethanol plants in operation 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]



Source: Renewable Fuels Association

Figure 1. Historical ethanol production (millions of gallons)

As noted by Hahn & Cecot (2009), the continued growth of the ethanol industry is

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

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 & 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 five percent) in 2009 (Urbanchuk, 2010).

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 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 have validated 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 & Griffith, 2005; Runge & 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 & Cecot, 2009). Specifically, Gardner (2007) concluded that the federal subsidies and mandates in the ethanol industry generate long-run deadweight losses between three and four billion dollars annually. Likewise, Hahn & Cecot (2009) estimated that the costs of increasing ethanol production to ten billion gallons per year (e.g. production costs, distribution costs, and increased emission costs) would exceed benefits (e.g. oil displacement, greenhouse gas emission reductions, and air toxic emission reductions) by three billion dollars annually in 2012 (holding policies fixed).

Although research highlighting the industry's negative impact is growing, one subject with minimum 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. While Turnquist, Fortenbery, & Foltz (2008) have considered this issue at the municipal level, providing a good first approximation of anticipated effects and insight into what might be observed, a detailed analysis at the property level is required to fully understand and capture the industry's effect on the value of residential properties.

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 be willing to live with the smell.[2] Beyond this, two additional negative externalities that may depress property values include: 1) toxic emissions could escape the plant requiring evacuation for a large radius surrounding the plant, and 2) increased truck traffic with associated noise and safety concerns.

[2] Studies that have examined the negative effect of smell and air quality on property values include: Harrison & Rubinfeld (1978), Nelson (1978), Zabel & Kiel (2000), and Saphores & Aguilar-Benitez (2005). Although the variables used, areas of study, and methods employed differ among these studies, the results were generally negative and statistically significant.

This study recognizes the externalities ethanol plants may impose on residents and provides the first in-depth 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 already 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. Hedonic analysis has a long history and has been used to measure numerous externalities on property values, ranging from the positive effect of community gardens (Been & Voicu, 2006) to the negative impact of hazardous waste sites (McCluskey & Rausser, 2003). Using a 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 a ten-year period provides greater confidence that any observed negative effect is truly the result 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. These conditions include, but are not limited to, the inability to see the plant and the existence of pre-existing industry in the general proximity of the new ethanol plant.

The following section provides an overview of all studies that consider the effects of ethanol plants on neighboring property values. A review of these studies highlights the need for an in-depth, property level analysis. In addition, this section includes a survey of previous literature examining the impact of local negative externalities. Among these, special attention is given to the techniques used and the wide range of findings. Section 3 focuses on the hedonic method and how it allows researchers to monetize different property attributes, including negative externalities. Details regarding the specifications 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 Negative Effects of the Ethanol Industry

The negative effects of the ethanol industry that have been examined by researchers include: costs 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 still not yet well understood. Of these four studies, only two are directly relevant to the issue of residential properties; two studies examine the impact of ethanol plants on agricultural land (Henderson & Gloy, 2008; Blomendahl & Johnson, 2009). The two studies examining farmland are less relevant to the present study as the value of residential property is based on its housing attributes while agricultural property is valued on its anticipated future earnings. Stemming from this difference, the opposite effect of an ethanol facility on farm properties is expected because higher expected returns are anticipated as demand for local corn may increase with the introduction of a plant (McNew & Griffith, 2005).

Turning our attention to those studies highlighting the impact of an ethanol plant on residential property values, the first study 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, & Foltz (2008). First, the methodology of the consulting firm was not described in the report and thus the conclusions are 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.[3] Therefore, a 2007 report estimating the impact of an ethanol plant in Texas cannot measure the effects of an operational plant. It is possible that the authors extrapolated from other types of refineries found in Texas, but even so, the effect of an ethanol refinery may be quite different than other types of refineries.

Given the shortcomings of the 2007 report, the remaining investigation by Turnquist, Fortenbery, & 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

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

distances from the plant to each municipality. The authors note that municipalities closest to ethanol facilities experienced continued growth in residential land values after the plant began operations; however, the growth appeared to be less than municipalities further away. Specifically, municipalities closest to the plant experienced growth rates of fifty percent while municipalities in the rest of the state experienced growth rates of eighty percent. 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 Measuring the Effect of Negative Externalities on Property Values

Beyond the ethanol industry, a number of studies have investigated the effect of positive and negative externalities on surrounding property values. Among such studies a wide range of methods have been employed, from surveys to hedonic models. Also, numerous types of externalities have been examined, from the negative impact of incinerators (Kiel & McClain, 1995) to the positive effect of open space (Bolitzer & Netusil, 2000). For reasons previously discussed, it is anticipated that the impact of an ethanol plant on residential properties will be negative, and thus this section provides a brief survey of previous studies focused on the effects of localized negative externalities. Special attention is given to the various techniques that have been implemented to measure negative effects on neighboring property and the range of results (even among studies examining the same type of externality).[4]

In a foundational paper, Blomquist (1974) measured the effect of an electrical power plant on neighboring property values. Employing the hedonic technique, Blomquist's model used the average value of houses within a census block as the dependent variable and the "effective distance" from the power plant as the key independent variable to capture the power plant's effect. The effective distance equaled the actual distance from the plant for those properties less than 11,500 feet away and equaled 11,500 feet for properties farther away. His report concluded that properties within 11,500 feet increased in value by nine-tenths of a percent for each additional ten percent increase in distance from the plant.

Nelson (1981) and Gamble & Downing (1982) examined the impact of the Three Mile Island incident on neighboring property values. In addition, Gamble & Downing studied the impact of nuclear reactors without accidents. Rather than follow the approach of Blomquist and use average prices at the block level, both studies set a new standard by employing individual house sales as their unit of observation. Among the independent variables, Nelson employed two variables to capture the impact of the plant on neighboring properties. The first was a dummy variable indicating whether or not the house was sold before or after the accident. The second was an interaction of the indicator variable with the date of sale, to capture the changing impact of the plant over time. Gamble & Downing also used two different variables to examine the effect of the nuclear plant. The first was an indicator variable representing properties from which one could see the plant and the second was distance from the plant. Both studies concluded that nuclear reactors did not have the anticipated negative impact.

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[4] For an extensive discussion on studies measuring local externalities and their results, see Sirmans, Macpherson, & Zietz (2005). Also, see Boyle & Kiel (2001) or Jackson (2001) for an extensive survey of studies examining the impact of environmental externalities (e.g. air quality, water quality, and undesirable land use).

Since Gamble & Downing's study, a broad range of research measuring the impact of negative externalities on neighboring property values has been completed. Although not an exhaustive list, these studies examined the effects of the following negative externalities: hazardous waste sites (McClelland, Schulze & Hurd, 1990; Michaels & Smith, 1990; Smolen, Moore, & Conway, 1992; Thayer, Albers & Rahmatian, 1992; McCluskey & Rausser, 2003); landfills (Nelson, Genereux, & Genereux, 1992; Reichert, Small, & Mohanty, 1992); natural gas facilities (Flower & Ragas, 1994; Boxall, Chan, & McMillan, 2005); and superfund sites (Kohlhase, 1991; Kiel, 1995; Deaton & Hoehn, 2004). Although the externalities being studied were different, conclusions were generally the same with most studies indicating a statistically significant negative effect on property values.[5] However, the spatial ranges and monetary impacts varied greatly. As an example of the variation in spatial ranges, Nelson, Genereux, & Genereux's (1992) study estimated that the impact of landfills reached homes within two miles of the site, whereas Kohlhase's (1991) study on toxic sites estimated that the impact was felt up to six miles away. As an example of the price differentials examined, Michaels & Smith's (1990) study on hazardous sites estimated that the benefit for each additional mile from the site was $115 while Smolen, Moore, & Conway's (1992) study on hazardous sites estimated a benefit of $9,000-14,000 for each additional mile. Observing large differences in monetary and spatial impacts, even within similar site studies, is not surprising. Each area being studied at different time periods is unique. The price consumers are willing to pay for a given bundle of attributes (or even a single attribute) will differ as tastes and preferences change across time and space (Sirmans et al, 2005).

[5] The only study that did not have the value of the property increase as the distance from the site increased was that of Flower & Ragas (1994). The authors concluded that more prestigious neighborhoods, as well as other positive influences, caused the unexpected result.

2.3 Contribution

The present study adds to both lines of research discussed above. In terms of research examining the ethanol industry, little is known about how ethanol plants affect residential property values. This is an important consideration if we are to fully understand the potential economic costs imposed by the industry. With regard to the general research implementing hedonic methods to examine the impact of negative externalities, this work provides a simple and unique method to evaluate the impact by allowing within-community comparisons before and after the plant begins production. Although including data before an externality exists is not required to implement the hedonic approach, doing so allows the researcher to make within-community comparisons across time and reduces potential concerns that the negative effect is caused by some unknown, pre-existing factor at (or near) the site.

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 ($H = h_1, h_2, \ldots, h_n$). 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 determine how much a house is worth ($P_H = \sum_{i=1}^{n} p_i$) (Brasington & Hite, 2005; Kashian, Eiswerth, & 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 [$P(H)=F(h_1, h_2, \ldots, h_n)$]. 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

[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 & Henning, 1967), he was the first to support interpretation and estimation through a well-defined theoretical model.

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).

In addition to estimating the implicit marginal price of each attribute, hedonic analysis may include a second stage to recover the inverse demand functions for individual attributes. To recover the demand functions, the implicit prices calculated in the first stage are regressed against observed quantities and socioeconomic characteristics of the consumers (Freeman, 1979). However, as highlighted by Malpezzi (2003), reliable second stage estimation is difficult as it is plagued with identification problems, imperfect specifications, and non-robust coefficient estimates. For these reasons, the second stage estimation is rarely used. Like previous studies examining the impact of negative externalities on house prices, this study focuses solely on the hedonic method's first stage to estimate the marginal impact of the ethanol plant on the price of neighboring properties.

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:

$$PRICE_i = \alpha + \sum_{j=1}^{m} \beta_j X_{ij} + \sum_{l=1}^{n} \gamma_l L_{il} + \delta_1 preD_i + \delta_2 DISTpre_i +$$

$$\delta_3 DISTpost_i + \delta_4 DISTpost_i^2 + \sum_{t=1}^{k} \theta_t Time_{it} + \varepsilon_i \qquad [1]$$

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 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 on 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, 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.

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

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 in operation. 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.

Three hedonic studies could be found that explicitly measure the impact of projects at different stages. First, Smolen, Moore, & 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 used as comparisons. As noted above, differences between communities may exist and direct comparisons may not be made unless all differences are accounted for.

Second, McMillen & 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 & 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 since the smelter was located in an otherwise attractive location. McMillen & Thornses use a similar technique as employed in the present study; however, they examine the removal of a negative externality rather than the introduction of a negative externality.

Finally, Kiel & 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 & McClain's general results into consideration and implements two time periods (pre- and post-production).

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:

$$PRICE_i = \alpha + \sum_{j=1}^{m} \beta_j X_{ij} + \sum_{l=1}^{n} \gamma_l L_{il} + \delta_1 preD_i + \delta_2 DISTpre_i + \sum_{r=1}^{d} \rho_r Ring_{ir} + \sum_{t=1}^{k} \theta_t Time_{it} + \varepsilon_i \qquad [2]$$

where $PRICE_i$, X_{ij}, L_{il}, $preD_i$, $DISTpre_i$, $Time_{it}$, and ε_i are the same as 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 (Palmquist, 1984; Pollakowski, 1995; Brasington & 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 include: 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 more a 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 when the size of the structure is included due to collinearity (McClelland, Schulze, & 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 & Hite, 2005). Nonlinearities are expected due to diminishing returns in consumption (Witte, Sumka, & 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 include: 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 post 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

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[8] Direction of the property from the plant was also considered, but Abeles-Allison & Connor (1990) have shown this to not be statistically significant in their study examining hog farms. Furthermore, there exist a small number of observations downwind from the ethanol plant (see page 25) and inference based on only a few observations would be unreliable.

appropriate functional form (Cropper, Deck, & 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, & Vukina, 1997). Following previously cited literature, two functional forms were considered: linear and semi-log (natural logarithm of the dependent variable). 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 & 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 and 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]

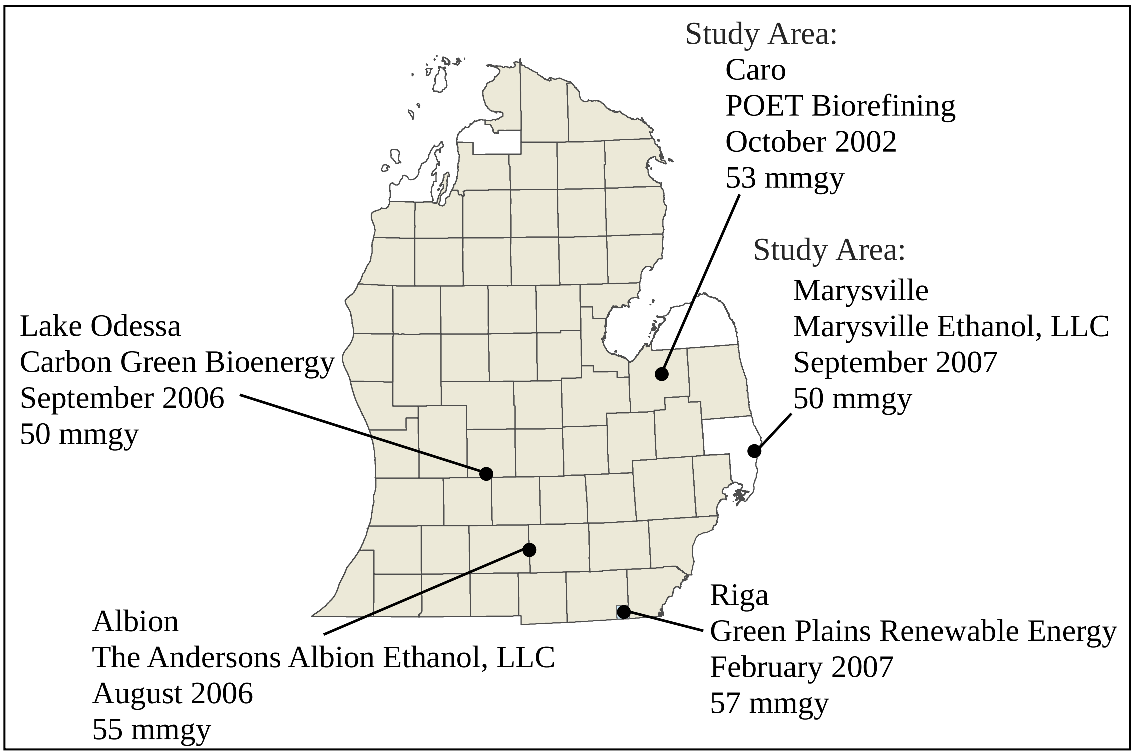

Figure 2. Michigan ethanol plants location, name, start date, and nameplate production capacity[10]

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[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] There are currently no plants in Michigan's Upper Peninsula.

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.[11] 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).

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.

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

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

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 & 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 primarily based 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 & Connor, 1990; Palmquist, Roka, & Vukina, 1997; Herriges, Secchi, & Babcock, 2005). An additional 43 observations were excluded for Caro, and zero for 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 were 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.[12] 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 and maps detailing the location of the dropped properties in relation to the ethanol plant are provided in Appendix 1.

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 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-

[12] 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 & Ritchie, 2010).

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. As highlighted in the literature review, the impact of the power plant is anticipated to be negative (Blomquist, 1974).

Figure 3 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 included and their definitions can be viewed in Appendix 2. Appendix 3 and 4 provide the summary statistics for Caro and Marysville, respectively.

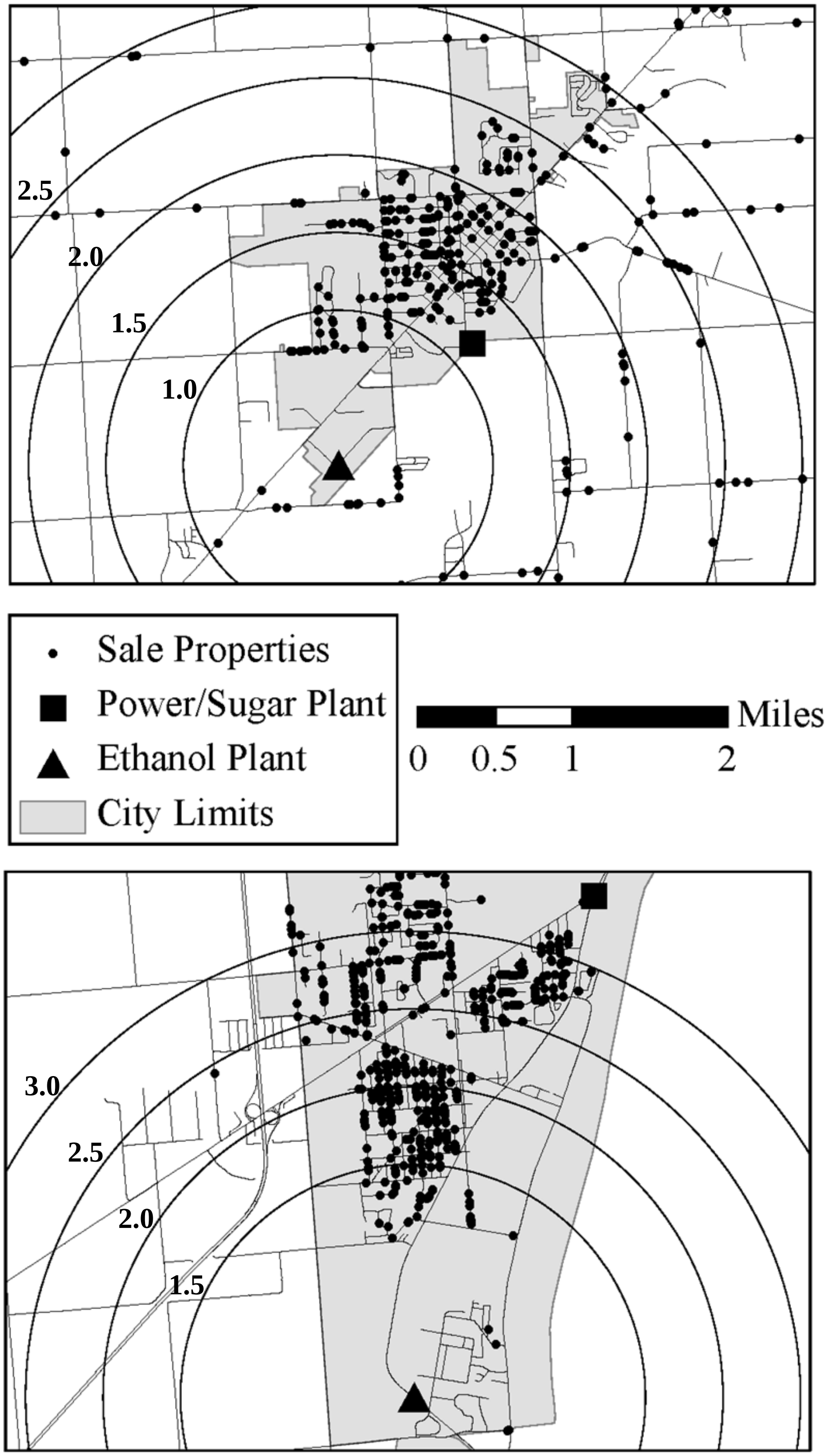

Figure 3. Location of select properties in Caro (above) and Marysville (below)

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 5 and the results for Marysville are presented in Appendix 6. 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, 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.[13] The impact of age on the house is the only negative effect among the structural

[13] 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. For example, to estimate the impact of an additional square foot on the value of the average house from column 1 in Appendix 5, the following calculation must be made: % change = [(coefficient from *LivingArea*) + (2*coefficient from squared $LivingArea^2$*$LivingArea$)]*100. Using this equation yields: % change = [(0.0006) + (2*-0.0000000878*1440)]*100 = 3.47%,

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 Halvorsen & 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.[14]

As shown in Appendix 5, two structural characteristics that are not statistically significant include: *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, & Skidmore, 2006; McClelland, Schulze, & Hurd, 1990).[15]

Turning attention to the year indicator variables which capture market trends, the only years that are statistically different than the base year (1999) include: 2002 and 2006-2009. Each coefficient is negative, and from 2006 to 2009 a larger negative impact is observed for each

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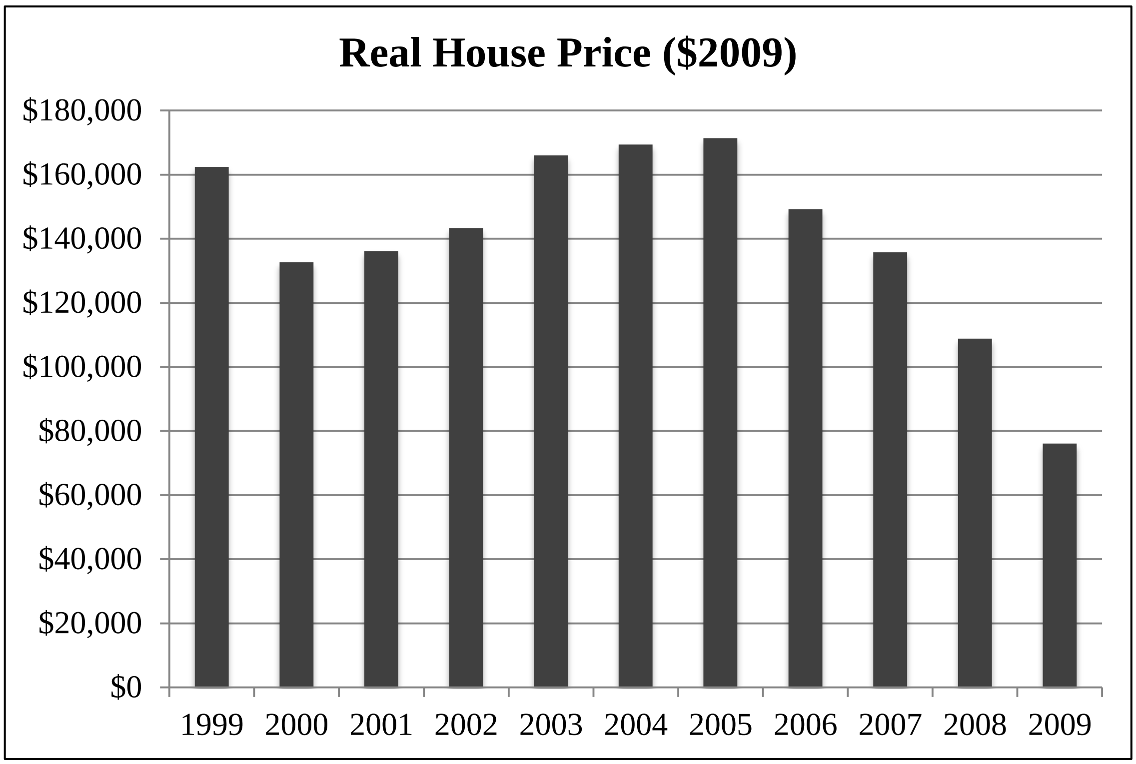
where 1440 is the average living area from the summary statistics provided in Appendix 3. Multiplying this by the average house price ($103,380) gives an increase of $36 per square foot, on average.

[14] 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.

[15] Furthermore, correlation tests between these variables were significant at the one percent level.

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.



Source: Michigan Association of Realtors

Figure 4. Average house prices for the Caro area[16]

[16] 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).

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* 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, the range in distance that houses are 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 added to 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 shown in columns 3 and 4 of Appendix 5, 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

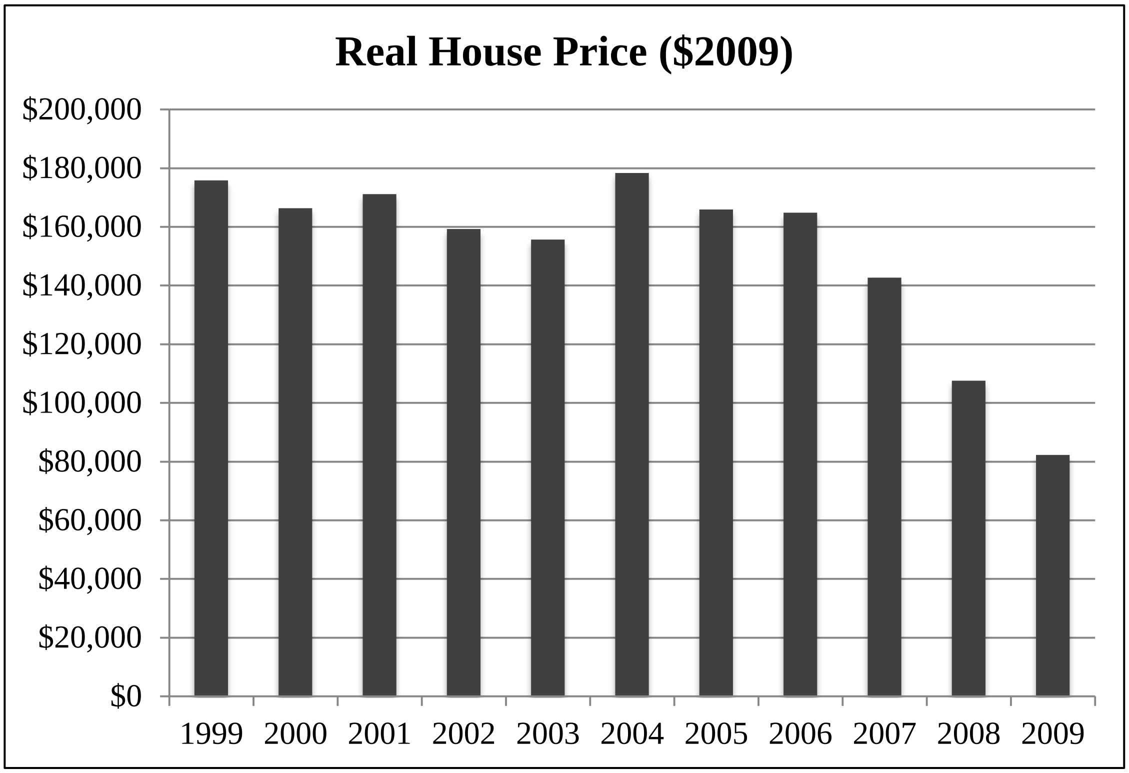
Examining the Marysville estimates and comparing them with Caro confirms that tastes and preferences differ among consumers as the price consumers are willing to pay for a given bundle of attributes (or even a single attribute) differ. The most striking differences are those that change statistical significance, including: *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 their 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.[17]

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, these are not unreasonable estimates as Figure 5 shows the yearly trends in the Marysville housing market.

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



Source: Michigan Association of Realtors

Figure 5. Average house prices for the Marysville area

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 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.

The coefficient for *River*, indicating the properties 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. If a large number of the properties within one-half mile are without access or a view, there is no reason to anticipate a positive effect. In fact, a negative effect could be anticipated as the properties could be in the floodplain. 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 1 and the majority of properties within one-half mile of the river are farther than two-tenths of a mile. These properties may cause the observed negative effect. To confirm these suspicions, Table 2 shows the coefficients of each new variable by including them into the regressions from Appendix 6. As the results show, the river has a positive effect on properties closest to the river.

Table 1. 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 2. Further examination on 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)

Table 2 (cont'd)

River5	-0.1023*** (0.0371)

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.

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, several rings representing interval distances from the plant have been added to the regression. One key difference exists between the rings created for Marysville and Caro: the first ring for Marysville (*Ring1.5* in Appendix 6) 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 6, 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 have been 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 Marysville plant (less than one percent of all observations). 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), as observed with other attributes 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 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 perceived negative externalities. All three of 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 are 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, these impacts have been shown to not be universal, probably because consumer tastes and preferences differ across time and space. In addition, inconsistent impacts may stem from the physical surroundings of ethanol plants such as vegetation and the existence of other industries across communities.

These findings have practical significance for community planners considering whether to allow a plant to locate in their community and 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 include this cost in terms of property taxes. If property values are decreasing as a result, homeowners and the community may experience negative effects as 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 the plant begins production. Using this approach helps to assure researchers, decision makers, and others that any observed negative impact is not the result of other pre-existing conditions in the community.

APPENDICES

APPENDIX A

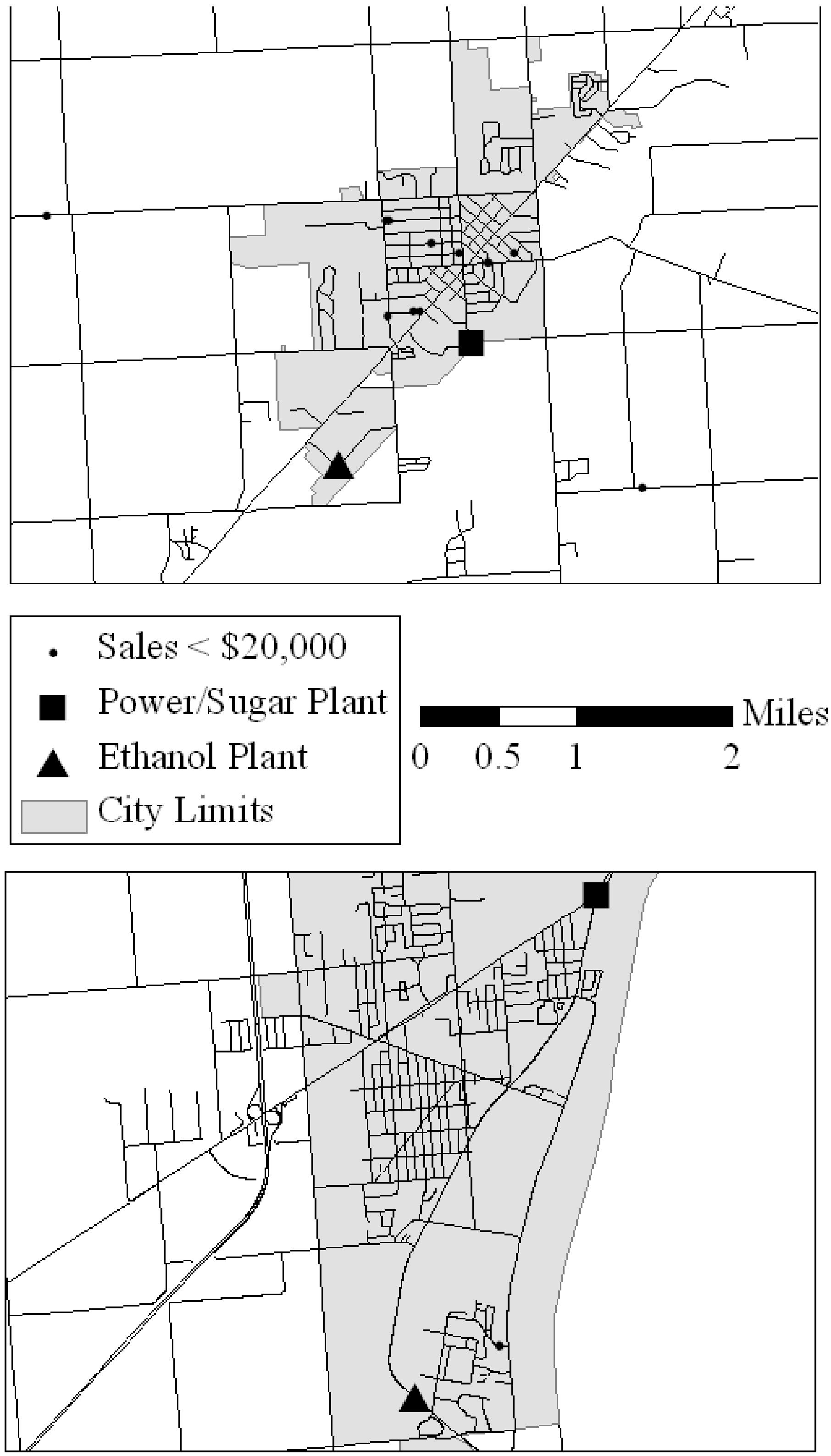


Figure 6. Property sales less than $20,000

APPENDIX B

Table 3. 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).
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.

APPENDIX C

Table 4. Caro summary statistics

Variable	Mean	Std Dev	Min	Max
REALPRICE	103,380	47,888	20,000	414,496
LivingArea	1440	533	540	5000
LotSize	1.49	2.10	0.07	10
Age	4.68	2.99	0	15
Bedrooms	2.99	0.77	1	6
Baths	1.60	0.59	1	4
Stories	1.26	0.40	1	3
Basement	0.71	-	0	1
Garage	0.75	-	0	1
AC	0.33	-	0	1
InTown	0.52	-	0	1
toTC	2.06	2.14	0	10.1
preD	0.22	0.42	0	1
DISTpre	3.00	2.16	0.76	10.85
DISTpost	2.73	1.85	0.26	10.85
Ring1	0.09	-	0	1
Ring1.5	0.18	-	0	1
Ring2	0.26	-	0	1
Ring2.5	0.08	-	0	1
Ring3	0.05	-	0	1
toSugarPlant	2.21	2.02	0.2	10
2000	0.01	-	0	1
2001	0.11	-	0	1
2002	0.11	-	0	1
2003	0.12	-	0	1
2004	0.11	-	0	1
2005	0.15	-	0	1
2006	0.13	-	0	1
2007	0.11	-	0	1
2008	0.09	-	0	1
2009	0.05	-	0	1
# of Obs.	611			

APPENDIX D

Table 5. Marysville summary statistics

Variable	Mean	Std Dev	Min	Max
REALPRICE	152,125	58,938	20,000	451,167
LivingArea	1380	459	550	4492
LotSize	0.25	0.23	0	3.86
Age	3.39	2.36	0	10
Bedrooms	2.94	0.66	1	6
Baths	1.79	0.68	1	4
Stories	1.31	0.42	1	2.5
Basement	0.78	-	0	1
Garage	0.87	-	0	1
AC	0.55	-	0	1
Condo	0.12	-	0	1
InTown	0.98	-	0	1
toTC	0.88	0.63	0.06	4.85
River	0.20	0.40	0	1
preD	0.82	0.38	0	1
DISTpre	2.43	0.82	0.63	5.56
DISTpost	2.48	0.87	0.63	5.56
Ring1	0.01	-	0	1
Ring1.5	0.14	-	0	1
Ring2	0.20	-	0	1
Ring2.5	0.14	-	0	1
Ring3	0.29	-	0	1
toPowerPlant	1.55	0.78	0	5.53
2000	0.03	-	0	1
2001	0.13	-	0	1
2002	0.12	-	0	1
2003	0.14	-	0	1
2004	0.09	-	0	1
2005	0.13	-	0	1
2006	0.11	-	0	1
2007	0.09	-	0	1
2008	0.08	-	0	1
2009	0.06	-	0	1
# of Obs.	885			

APPENDIX E

Table 6. 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)	-	-

Table 6 (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 F

Table 7. 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)

Table 7 (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			

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

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