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MEASURING INDIRECT BENEFITS OF BROWNFIELD
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THE CASES OF LANSING, MICHIGAN

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# MEASURING INDIRECT BENEFITS OF BROWNFIELD REDEVELOPMENT USING THE HEDONIC PRICE METHOD: THE CASES OF LANSING, MICHIGAN

By

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ABSTRACT

MEASURING INDIRECT BENEFITS OF BROWNFIELD REDEVELOPMENT USING THE HEDONIC PRICE METHOD: THE CASES OF LANSING, MICHIGAN

By

Young-Tae Kim

The main purpose of this study is to measure the indirect economic benefits of brownfield redevelopment by using the hedonic price method. The study analyzed impacts of brownfield redevelopment on the price of surrounding properties, using three brownfield redevelopment cases in Lansing, Michigan. The empirical findings of the hedonic price analysis confirmed the existing literature observing that the proximity to brownfield sites or environmental hazards was negatively related to the property values in nearby neighborhoods. The empirical findings of the analysis also supported the hypothesized relationship between the proximity to brownfield sites and nearby housing values before and after redevelopment. Redevelopment of brownfields was expected to provide positive impacts on the housing values in the surrounding neighborhood by eliminating or substantially reducing the negative externality associated with brownfields.

The analysis employed two different hedonic functional models to estimate the indirect benefits of three brownfield redevelopment projects: a linear functional model and a log-linear functional model. The results of the two analyses were consistent with each other, showing that the estimated total benefit of three redevelopment projects was $78,007,696 for the log-linear functional model and $85,962,590 for the linear functional model, in addition to the direct benefits of the projects such as the number of jobs created and increases in the tax base after redevelopment.

As this study confirms, the cleanup or redevelopment of brownfields provides indirect benefits that cannot be measured easily in the current market system. However, this kind of indirect benefit of brownfield redevelopment has not been an important consideration in the public decision-making framework. Without acknowledgement of the full potential benefits and costs associated with brownfield redevelopment, it is not possible to make an efficient allocation of resources in the public policy area. The empirical findings of this study can be used to justify public financial assistance for the cleanup or redevelopment of brownfields. The findings can also help government officials prioritize competing projects to use public resources more efficiently. This study also suggests that the estimated hedonic function can be used to determine the benefits of brownfield cleanup or redevelopment in the decision-making process.

However, some limitations were inherent in this study due to the small number of redeveloped brownfield sites. First, its empirical findings cannot be generalized as the indirect economic benefits of brownfield redevelopment and can only represent the impacts of three brownfield redevelopment case studies in Lansing, MI. Second, even though the study compared the benefits of three brownfield redevelopment cases based on their different redevelopment scenarios, the comparison should not be generalized due to the limited number of brownfield redevelopment cases in the study. The limitations of the study suggest that future researchers might consider analyzing the indirect economic impacts of brownfield redevelopment using a large number of redeveloped brownfields in various geographical locations, and contrasting hedonic price methods to other more descriptive approaches to measuring the indirect economic benefit of brownfield redevelopment.

DEDICATION

To my wife Jung Hee Choi, daughter, Bo Ra, and son Hyong Uk Kim

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# I. INTRODUCTION

## 1.1 Background

A brownfield, defined as "an abandoned, idle, or under used industrial or commercial property where expansion or redevelopment is complicated by real or perceived environmental contamination (EPA, 1996)," is a symbol of deterioration in many urban communities in the United States. Contamination in these brownfields may be found in various forms and degrees ranging from extremely hazardous contamination with heavy metals or chemicals to zero or suspected contamination with debris or eyesores of old buildings. These brownfields limit economic development opportunities and restricts urban revitalization while raising a variety of environmental and public health concerns. The Environmental Protection Agency (EPA) estimates that there are more than 450,000 brownfields nationwide.

The reuse or redevelopment of brownfields has not been an attractive option for property owners or prospective developers due to unanticipated effects of federal or state environmental legislation that regulates the management of hazardous wastes and contaminated sites. The important legislation that has major impact on the reuse of the contaminated sites includes the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), and state statues that regulate the management and cleanup of contaminated properties. The federal and state laws pose several barriers to the reuse or redevelopment of the contaminated sites, such as the uncertain cleanup standards, unknown or very high cleanup costs, potential liability risk to prospective purchasers or developers, and uncertain timeline of redevelopment.

CERCLA, which is commonly known as "Superfund", was enacted in 1980 as a congressional response to the "Love Canal" tragedy[1] and the growing concerns over closed or abandoned hazardous waste sites. CERCLA contains two main purposes. First, CERCLA establishes a tool to finance the government's cleanup of hazardous waste sites when no responsible party can be identified. Second, it provides a mechanism to recover the cleanup cost from all identifiable responsible parties. Since its enactment, CERCLA has had success in reducing human health risks and improving the environmental quality across the country. According to EPA, more than 900 sites were cleaned up and cleanup activities are underway at additional 422 sites in 2005 (EPA, 2005).

However, CERCLA's imposition of liability on all potential responsible parties for cleanup made it difficult to reuse the contaminated sites. The enactment of CERCLA dramatically changed the way of imposing legal liability for contamination or environmental injuries. First, CERCLA's liability is "retroactive and strict" since property owners can be held liable for contamination on their property even though their activities were legal at the time of contamination and were undertaken with all due care. CERCLA also imposes liability for cleanup on new property owners who purchased contaminated sites but had nothing to do with contamination. In addition, CERCLA's liability is "joint and several" because an individual or single party who is partly responsible for contamination can be liable for the full cleanup cost if there are no other responsible parties identified.

As a result, property owners, new investors, and developers have stepped away from the reuse or redevelopment of the contaminated sites in fear of potential liability for

[1] Love Canal is one of the biggest modern environmental disasters caused by hazardous chemical wastes. For detail information, see Beck, Eckardt, "The Love Canal Tragedy" in *EPA Journal*, January 1979.

contamination and the cleanup costs. Under CERCLA, all potential responsible parties include: the current owner or operator of the site, the past owner or operator, a person who arranged for the disposal of waste at a site, and a person who transported waste to a site.[2] CERCLA's strict and joint and several liability on these potential responsible parties made it difficult to transfer or redevelop the contaminated sites.

Many states also began to introduce their own laws similar to CERCLA because a lot of contaminated sites within their jurisdictions did not meet the criteria for being listed on the National Priority List (NPL)[3] of CERCLA. Even though these contaminated sites were not regulated under CERCLA, many of them were still considered as environmentally hazardous sites that imposed human health risk. The basic purpose of the state laws was to regulate these contaminated sites by imposing liability of cleanup on property owners or other responsible parties. Approximately forty five states[4] introduced their own state superfund laws that are very similar with CERCLA. In general, they contain the following features: procedures for emergency response and permanent cleanup, provision of financing sources for cleanup, enforcement authority to regulate the contaminated sites, and provision for public participation in the cleanup process (Geltman, 2000: 69).

The so-called state superfund laws along with CERCLA made it more difficult to reuse the contaminated properties by imposing stringent cleanup standards and liability for property owners and prospective developers. Acknowledging the barriers to the reuse

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[2] See CERCLA Section 107 (2) for details.

[3] The NPL is a list of contaminated sites, published by USEPA, which pose an immediate or significant pubic health threat. NLP sites are eligible for extensive, long-term cleanup action under CERCLA.

[4] "Forty one states have strict liability, and thirty six have several and joint liability to allocate responsibility for costs among responsible parties. Forty-three states impose retroactive liability. Thirty-two states have authority to recover for damages to natural resources." (Hula, 2003: 4)

of the contaminated properties, several states took a lead in encouraging the reuse or redevelopment of these sites by establishing their own voluntary cleanup program (VCP). Approximately twenty one states enacted state voluntary cleanup programs and fifteen states introduced brownfield economic redevelopment programs to facilitate the reuse or redevelopment of the contaminated sites (Geltman, 2000: 81). The state programs focus on relieving the cleanup liability, introducing flexible cleanup standards, and providing financial incentives for site assessment and cleanup activities.

Michigan is one of the leading states in promoting brownfield redevelopment. Michigan along with some other states in the Midwest region pioneered innovative and effective approaches to encourage and facilitate the redevelopment of properties that were environmentally degraded and contaminated with heavy metals, chemicals, and petroleum constituents due to previous manufacturing and other old industrial activities[5]. Michigan established its own voluntary cleanup program and provided several grant and loan programs that are available to local units of government along with other public incentives to attract private investment on brownfields. Table I-1 shows Michigan's programs for brownfield cleanup and redevelopment.

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[5] See "Chapter 8. Region V: Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin" in *Recycling Land: Understanding the Legal Landscape of Brownfield Development* for the brownfield redevelopment efforts of the Midwest states (Geltman, 2000: 199-233).

Table I-1 Michigan's Programs on Brownfield Redevelopment

| Financing Programs | Voluntary Cleanup Programs | Other Incentives |
|---|---|---|
| • Site Reclamation/Site Assessment Grant Program<br>• Cleanup and Redevelopment Fund<br>• Revitalization Loan Fund<br>• Brownfield Redevelopment Authorities (Tax Increment Financing)<br>• Clean Michigan Initiatives | • Part 201 of Natural Resources Environmental Protection Act (1994, amended in 1995) | • 10% Single Business Tax Credits ($1 million cap) for innocent party's development costs on a property. |

Source: Modified from Northeast-Midwest Institute. 1999.

Michigan first began to regulate the cleanup process of brownfield sites by enacting a state superfund law, the Michigan Environmental Response Act (MERA) of 1982, known as Public Act 307. Like most state superfund programs, MERA established a process for assessing risks and providing for response activity at environmentally contaminated sites. MERA imposed liability for cleanup on owners or operators of the contaminated sites or facilities and provided a means for public financing of remedial actions at the contaminated sites. MERA also set standards for cleanup of the contaminated sites. The Michigan superfund law was amended to introduce strict joint and several liability for potentially responsible parties in 1992.

As CERCLA and most state superfund programs were criticized in the mid 1990s due to their unanticipated effects on the reuse of the contaminated sites, Michigan began to find more innovative approaches to govern the contaminated sites. MERA was amended in 1995 and became Part 201 of the Natural Resources and Environmental Protection Act known as Public Act 451. The amendment aimed at promoting the reuse of brownfields by relieving liability of property owners and operators, providing flexible cleanup standards, and reducing uncertainty and remediation costs.

First, Part 201 of PA 451 changed liability scheme significantly to facilitate transactions of the potentially contaminated properties and to promote brownfield redevelopment. Under Part 201, new property owners or operators of the contaminated properties are no longer liable for existing contamination as long as they did not cause the contamination. New owners who acquired the potentially contaminated properties after 1995 will not be liable for the existing contamination if they complete a Baseline Environmental Assessment (BEA). A BEA is an assessment of the existing environmental conditions of a property at the time of property transaction. The BEA must be conducted no later than 45 days after purchase, occupancy, or foreclosure of the property. The properly conducted BEA will provide new property owners with liability protection for existing contamination. In exchange for liability protection, new owners are obligated to exercise "due care" with regard the existing contamination.

Part 201 also introduced flexible cleanup standards, by taking into account future use of the contaminated properties. The Michigan Department of Environmental Quality (MDEQ) is authorized to establish cleanup standards based on land use-based categories. MDEQ set three main categories of land use-based cleanup standards: residential, commercial, and industrial.[6] There are also three additional categories of cleanup standards in case there is a need to restrict property use beyond the current land use regulations. The three additional categories are limited residential, limited commercial, and limited industrial. Under this land use-based cleanup standard provision, property owners can reduce the cleanup costs significantly by choosing an appropriate category of cleanup standard based on the intended future use of the properties.

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[6] Michigan also allows cleanups based on recreational land use but the standard has not been developed.

In addition to the state VCP, Michigan also developed various public financing programs to attract private investment on brownfields. Michigan is one of the pioneering states that developed grant programs to facilitate brownfield redevelopment. In 1988, Michigan introduced two grant programs: the Site Reclamation Grant (SRG) and the Site Assessment Grant (SAG). Michigan legislature appropriated a total of $45 million in the Environmental Protection Bond Fund of 1988 for the two brownfield grant programs. The SRG program provides funding up to $2 million to local units of government to investigate and remediate known sites of environmental contamination, which can be used for identified economic redevelopment projects. The SAG program provides grants up to $1 million to eligible local units of government to assess the nature and extent of contamination at properties with economic development potential. Michigan voters also approved a $675 million bond, the Clean Michigan Initiative (CMI), in 1998. As part of the CMI, a total of $335 million was earmarked for various brownfield programs including the Environmental Cleanup and Redevelopment Program, the Brownfield Redevelopment Grant and Loan Programs, and the Landfill Grant Program.

Another important financing source for brownfield cleanup or redevelopment is local brownfield authorities (BRAs), which are created by municipal and county governments under the 1996 Brownfield Redevelopment Financing Act. The Brownfield Redevelopment Financing Act creates a state Brownfield Redevelopment Board within MDEQ to oversee brownfield redevelopment and authorizes local governments to create their own BRAs, which are allowed to adopt brownfield redevelopment plans, and to capture tax increment revenues from functionally obsolete or blighted properties in order to pay for eligible environmental costs necessary for safe redevelopment of the properties.

Michigan's brownfield policies and programs have assisted in transforming a number of abandoned, idle, or underutilized properties into productive use. According to MDEQ (2008), Michigan has been provided about $927 million of state funding for cleanup or redevelopment activities of nearly 1,800 sites. Michigan's brownfield grant and loan program alone awarded about $143 million for 300 projects statewide. MDEQ (2008) estimates that the brownfield grants and loans have leveraged about $3 billion in private investment while creating more than 20,000 new jobs.

Hula (2003) shows the success of Michigan's brownfield programs after analyzing a state database of Baseline Environmental Assessments (BEAs). The BEA program is expected to facilitate transactions of the potentially contaminated properties by eliminating new owners' liability for existing contamination. Hula explored whether Michigan's BEA program attracts private investment for the reuse of those sites. His study analyzed a sample of 1,505 BEA sites selected from the state BEA database. His field visits to the sample sites identified that many BEA sites are fully redeveloped and approximately 79% of the sample sites are engaged in at least minimal economic activities. The study concluded that Michigan's brownfield programs help attract private investment on the potentially contaminated properties to some degree.

Moyhamed and Dancik (2007) also provide some evidence that shows the effectiveness of the Michigan's brownfield programs. They evaluated the investment impacts of the Site Assessment Grant (SAG) program by selecting a sample of 30 projects funded by the grant program. The study aimed to make suggestions for the future grant program based on analysis of the investment impact of the sample projects. The study employed several economic indicators to evaluate the economic impacts of the program. These indicators included the status and types of redevelopment, the number of new jobs, and increased property tax revenues. The study found that the 30 projects generated over $6.5 million in gross property tax revenues and created 124 new jobs as of 2005. The study also pointed out that the SAG program was helpful for transferring property ownership from local governments to private parties. Based on their findings, Moyhamed and Dancik concluded that the grant program is worth continuing due to its positive impacts on brownfield redevelopment.

As these studies briefly indicate, Michigan's brownfield programs play a positive role in developing and reusing potentially contaminated properties. The reuse or redevelopment of these sites provides numerous direct or indirect benefits to not only individual property owners but also an entire community considering the pervasive problems of brownfields throughout the entire community. These benefits include retention/recovery of the local tax base, job creation, re-use of existing infrastructure, and health and environmental benefits to the community.

Despite the direct and indirect benefits anticipated, it is not easy to assess all possible impacts of individual brownfield redevelopment projects. As Moyhamed and Dancik (2007) showed, the most common approach is to develop simple indicators, which measure the possible direct outcome of brownfield redevelopment. Some examples of indicators for measuring direct impacts of brownfield redevelopment include: income from new jobs created during or after redevelopment; sales from new business establishments on sites; new sales, income, and business taxes generated from redeveloped sites; changes in property values; and increased local property taxes. The direct impacts of brownfield redevelopment can be measured relatively easily using a set of these indicators.

However, these simple indicators cannot fully reflect the environmental and socioeconomic impacts of brownfield redevelopment projects. Beyond the direct benefits, brownfield redevelopment can have indirect impacts on the nearby neighborhood or the community by reducing health risks or improving the local environment or amenity due to cleanup of contamination or removal of disamenities. In theory, these indirect impacts are types of externalities, which arise when the actions of individuals produce incidental effects to others without intention.

## 1.2 The Purposes and Limitations of the Study

This study is an attempt to measure the indirect impacts of brownfield redevelopment projects in Michigan using the hedonic price method. Since the indirect impacts cannot be captured in the market system directly, it is necessary to use either related goods or a survey based on a hypothetical scenario in order to quantify these effects economically. The former method is the hedonic price method; the latter is the contingent valuation method. This study uses the hedonic price method, which has been wisely used to assess the value of environmental goods such as amenities or improvement of environmental qualities.

The hedonic price method was introduced comprehensively for the first time in the 1960s and 1970s by Griliches (1971) and Rosen (1974). After Griliches attempted to measure the price changes of commodities as price index, Rosen formulated the underlying theory of the hedonic price method, which determines the bid prices or implicit value of the attributes, or characteristics of a commodity in competitive markets. In principle, the hedonic price method assumes that certain commodities such as housing or land are made up of different bundles of attributes that can have an impact on the commodity values. Using this assumption, the hedonic price method seeks to determine the implicit price of each attribute by analyzing the relationship between different attributes and the price of the commodity.

After Rosen's comprehensive formulation of the theory, many studies[7] used the hedonic price method to measure the values of environmental amenities or disamenities. In general brownfields are considered as disamenities and the benefit of clean-up of brownfields has been documented in the existing literature by analyzing the impacts of brownfields on surrounding property values. It can be assumed that the proximity to brownfields is negatively related to the nearby property values and property values decrease as the proximity to a brownfield increases. Extending the assumption furthermore, the nearby property values once declined, would rebound if brownfields are cleaned up or redeveloped. Even though there are not many empirical studies that assessed the impacts of brownfield remediation or redevelopment on nearby property values, Grigelis (2005), Ihlanfeld and Taylor (2004), and Kaufman and Cloutier (2006)

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[7] Some examples of the environmental valuations with the hedonic price method include: the effects of hazardous waste disposal (Adler et al. 1982, Smith and Desvousges, 1986), benefits or costs of noise reduction (O'Bryne et al. 1985, Espey and Lopez, 2000, Becker and Lavee, 2003), the benefits of air quality (Kim et al. 2003), the effects of water quality (Leggett and Bockstael, 2000), the value of scenic beauty or amenity (Smith and Palmquist, 1994, Cheshire and Sheppard. 1995, Bishop, 1996, Tyrvainen 1997, Tyrvainen and Miettinen, 2000), the impact of open space or green space (McPherson, 1992, Riddel, 2001, Smith et al. 2002, Morancho, 2003, Tajima, 2003), the demand function of public school quality (Brasington, 2002, Downes and Zabel, 2002.), the impact of nuclear facilities (Clark et al. 1997, Gawande and Jenkins-Smith, 2001), and the impact of hazardous waste sites or brownfields (Michaels and Smith, 1990, Kohlhase, 1991, Patchin, 1991, Kiel, 1995, McCluskey and Rausser, 1999 & 2003, Kiel and Zabel, 2001, Deaton, 2002, Corona, 2004, Ihlanfeldt and Taylor, 2004, Grigelis, 2005, Longo and Alberini, 2005, Kaufman and Cloutier, 2006)

concluded that the effects of brownfields are substantial and significant economic benefits will be expected from the remediation or redevelopment of brownfields.

However, there is another argument that property values may not be fully recovered even though brownfields are cleaned up or redeveloped. Patchin (1991), Kiel (1995), and McCluskey and Rausser (2003) provide some evidence that remediation of contaminated commercial and industrial properties does not always lead to a full recovery of the property's own value due to "stigma" effects. Some studies show that there is no evidence that the removal of negative externalities is substantially capitalizing into the real estate market (Corona, 2004, Longo and Alberini, 2005) and brownfield remediation or redevelopment does not always lead to a rebound in property values in surrounding communities.

This study reexamined whether redevelopment of brownfields provides positive impacts on surrounding property values. The impacts of three brownfield redevelopment cases on their surrounding residential property values were assessed by estimating hedonic functions for 8,458 housing sales observations from 1998 to 2007 in Lansing, Michigan. The study first hypothesized that the brownfields had negative impacts on their surrounding property values before redevelopment due to negative externalities associated with the brownfields. The analysis also tested to see if the redevelopment of brownfields recovers the loss of surrounding property values by eliminating or substantially reducing the negative externalities. The study was able to provide empirical evidence for indirect economic benefits of brownfield redevelopment, finding positive impacts of brownfield redevelopment on the surrounding property values. In addition, the study was able to provide a relative comparison on the benefits of three brownfield redevelopment cases based on different redevelopment scenarios including different end uses and sizes of three brownfield sites.

This study expected that its empirical findings would help state and local governments have a better understanding of benefits of brownfield redevelopment. In general, the indirect benefit has not been considered as an important factor in the decision making process partly because it is not easy to quantify the indirect benefit. This stems from perhaps due to the nonmarket nature of "commodity goods". This study as well as the existing literature proved that such indirect benefits can be measured by using the hedonic price method. The ability to measure the indirect benefits from brownfield redevelopment provides justification for including these benefits in the decision-making framework of public policy.

However, this study contains the following limitations. First, since this study used a small number of brownfield redevelopment cases in a single geographical location, its empirical findings cannot be generalized. Second, even though the study compared the benefits of three brownfield redevelopment cases based on their different redevelopment scenarios, the comparison should not be generalized due to the limited number of brownfield redevelopment cases of the study. The limitation of the study suggest that future researchers might consider analyzing the indirect economic impacts of brownfield redevelopment using a large number of redeveloped brownfields in various geographical locations.

The remainder of the study is organized as follows. Chapter II introduces the theoretical background of the hedonic price method as well as reviews in detail the literature on the impact of brownfields on surrounding property values. Chapter III describes the methodology of this study, including study areas, data, and hedonic price models used for the empirical analysis. Chapter IV presents the empirical results of the study and key findings. Chapter V provides a summary of key findings and what the findings mean for research and policy.

# II. LITERATURE REVIEW: THE ECONOMIC IMPACTS OF BROWNFIELD REDEVELOPMENT & THE HEDONIC PRICE METHOD

## 2.1 The Economic Impacts of Brownfield Redevelopment

Brownfield redevelopment, which aims at revitalizing urban communities as well as improving environmental qualities, has become an important policy for federal and state governments. Due to the additional costs and financial risks associated with brownfield redevelopment, public financing and other assistance are essential to encourage the conversion of brownfields to productive properties. Federal and state brownfield programs focus on reducing financial burdens and relieving other risks for property owners or developers ranging from direct financial assistance to other incentives including technical assistance.

According to the EPA (2005), more than 20 federal agencies maintain financing and other service programs available for brownfield remediation and redevelopment. The EPA alone has provided a total of $454.8 million to support assessment, clean-up, or redevelopment of brownfields since the beginning of its brownfield program in 1995. The EPA's direct funding assistance has leveraged more than $8.2 billion in private investment for 8,467 brownfield sites over the same time period.

State governments also offer a variety of financial and technical assistance to promote remediation and redevelopment of brownfields (EPA, 2007). According to one study (Bartsch and Wells, 2003), 23 states provide some form of tax incentives and 22 states offer financial assistance to promote brownfield remediation and redevelopment. In addition to the efforts of federal and state governments, local governments complement the federal and state programs by providing direct financial assistance[8] and other tax incentives.

Due to supports from all levels of government, communities throughout the U.S. have been able to document their success stories of brownfield redevelopment since the 1990s. One survey revealed that 154 cities had developed 1,409 sites for a total of 10,905 acres. In addition, a total of 10,256 acres at 1,189 sites were in various stages of redevelopment (The U.S. Conference of Mayors, 2006). The remediation or redevelopment of brownfields is already providing economic benefits to the communities. According to the survey of the U.S. Conference of Mayors (2006), 62 cities reported $233 million of actual tax revenues generated from redeveloped brownfield sites. Also, 71 cities reported that 83,171 new jobs have been created from redevelopment of brownfield sites.

Despite widespread brownfield success stories throughout the U.S., it is not easy to quantify the effects of brownfield clean-up or redevelopment entirely. One reason is the lack of systematic data collection efforts. As Wernstedt (2004) addressed, "data collection and analysis are inconsistent across federal and state agencies, across programs in a single agency, and even within individual programs" (p.1). Another challenge is that some effects of brownfield redevelopment cannot be observed in the market system directly. As Wernstedt's survey showed, most direct economic benefits from brownfield redevelopment can be measured with such common economic indicators as the number of new jobs, increased income, the increased value of the sites, and the increased tax revenues from the redeveloped site. However, brownfield clean-up or redevelopment

[8] The main sources of local financial assistance for brownfield redevelopment include tax increment financing (TIF), general obligation bonds, and local revolving loan funds. (See Bartsch and Wells, 2003 for further information)

generates some other effects such as improvement of environmental amenities and reduction of health risks that cannot be captured in the market system directly. Since these effects have no market value, it is necessary to use either related goods or a survey based on a hypothetical scenario in order to quantify these effects economically. The former method is the hedonic price method; the latter is the contingent valuation method.

The contingent valuation method measures values of non-market environmental goods by analyzing individuals' responses to hypothetical questions regarding their willingness to pay for environmental goods. The hypothetical questions in general take the form of "How much would you pay if …?". Despite its usefulness for measuring value of environmental goods, the contingent valuation method has some issues and problems due to its nature of formulating the questions based on a hypothetical scenario. According to Goodstein (1999), there are at least four sources of possible errors identified from the previous contingent evaluation studies: free riding, strategic bias, hypothetical bias, and embedding bias. Free riding and strategic bias often occur when the actual outcome of individuals' responses can affect the provision of environmental quality or their actual payment for the environmental goods in question. In this case, the respondents may strategically understate or overstate their true willingness to pay. Hypothetical bias arises when respondents provide poorly thought out or meaningless answers to hypothetical questions. Embedding bias can be observed when individuals' responses are strongly affected by the amount of information about the environmental good in question. Despite these problems, as Goodstein (1999) pointed out, the contingent valuation method has been increasingly used "because it provides the only available means for estimating non-market benefits based primarily on existence value, such as the benefits of preserving the striped shiner" (p. 138). Goodstein (1999) also mentioned that much of the potential bias associated with the contingent valuation method can be overcome if hypothetical surveys are carefully designed.

Unlike the hypothetical nature of the contingent valuation method, the hedonic price method measures values of nonmarket environmental goods from observed market behavior using "the change in prices of related, or complementary goods to infer a willingness to pay for a healthier environment" (Goodstein: 140). As the word "hedonic" indicates, the hedonic price method has been used to measure the pleasure or utility associated with an improved environment. This study used the hedonic price method since its main purpose is to measure the indirect value of an improved environment, the redevelopment of brownfields.

## 2.2 The Hedonic Price Method & Brownfield Redevelopment

Even though the history of the hedonic price method goes back to the 1920s, it was Rosen (1974) who developed its theoretical framework comprehensively. According to Rosen (1974), "goods are valued for their utility bearing attributes" and "hedonic prices are defined as the implicit prices of attributes and are revealed to economic agents from observed prices of differentiated products and the specific amounts of characteristics associated with them" (p. 13). In his theory, a commodity ($A$) can be described by various attributes ($Z_i$) and expressed as $A = (Z_1, Z_2, Z_3, \ldots, Z_i)$. The hedonic price method estimates the implicit price of the attribute by using the following general form of the hedonic price function:

$$P_A = P(Z_1, Z_2, Z_3, \ldots, Z_i) \qquad (1)$$

Where $P_A$ is the price of the commodity $A$ and ($Z_1$, $Z_2$, $Z_3$, …, $Z_i$) are the various attributes associated with the commodity $A$.

Once the hedonic function of the commodity price and its attributes is established, the implicit marginal price of the attributes can be estimated after regressing the price of the commodity on its attributes. In other words, the implicit marginal price of the attributes is the partial derivative of the hedonic function with respect to each attribute and can be expressed as:

$$P(Z_i) = \partial P_A / \partial Z_i \qquad (2)$$ [9]

The final stage of the hedonic price method is to estimate the inverse demand function for the attribute $Z_i$ by combining the implicit marginal price and the quantity

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[9] To explain this in more detail, consider an individual who purchases the commodity $A$, with which all attributes ($Z_i$) are associated. If $X$ is all other goods consumed, the individual's utility ($U$) is given by

$$U = U(Z_i, X)$$

or

$$U = U(M - P_A, Z_i)$$

since the individual maximizes utility subject to the income constraint:

$$M = X + P_A$$

Then, a typical first order condition for the choice of attributes is $Z_i$

$$(\partial U/\partial Z_i)/(\partial U/\partial X) = \partial P_A/\partial Z_i = P(Z_i)$$

Thus, the partial derivative of the hedonic function represents the implicit marginal price of the attributes.

along with other exogenous variables. The demand function can be obtained by inverting the individual's utility function and holding all but attributes *i* constant.

The hedonic price method uses primarily the housing market to quantify the implicit values of environmental goods or services. As Freeman (2003) discussed, some environmental goods and services such as amenities, proximity to hazard, and air and water qualities are important attributes of a residential property and affect the productivity of the property. In this case, the market value of the property will reflect the productivity differentials caused by those environmental goods or services. The hedonic price method measures the value of environmental goods or services by determining the buyer's willingness to pay for such attributes in the housing market.

There are many studies that measure the disamenity effect of hazardous waste sites or contaminated sites in the literature. Many studies[10] assume that the existence of the hazardous waste sites can be considered disamenity factors to surrounding properties due to environmental harms, aesthetic disruption, and other social problems associated with these sites.

It can be further assumed that due to the disamenity effects, the proximity to these sites is negatively related to the nearby property values and property values decrease as the proximity to a hazardous waste site increases as Figure II-1 shows. In Figure II-1, the area $P_1P_2D_1$ represents the aggregate loss of housing value because of the existence of a hazardous waste site and is equivalent to the aggregated benefit of cleanup of the site.

[10] See footnote 7 (p 11) for some examples.

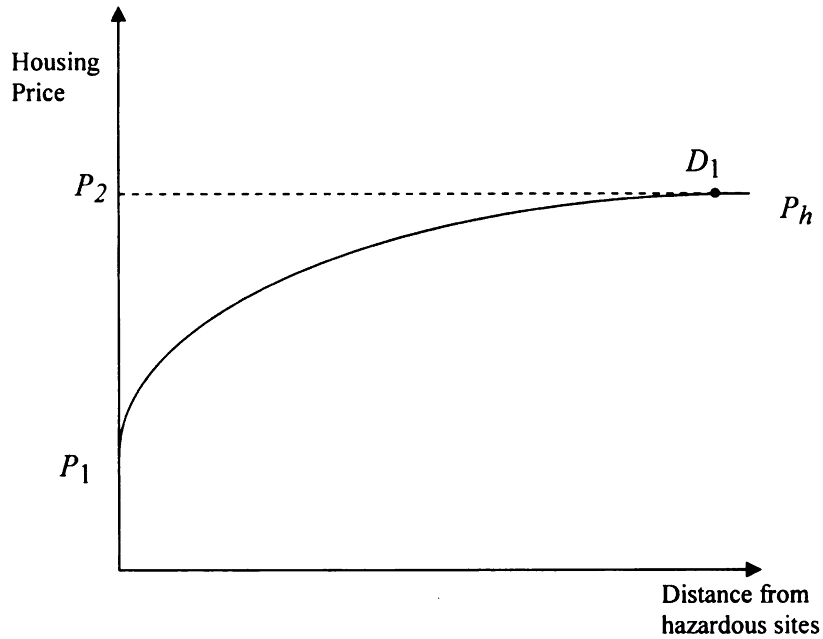


Figure II-1 Basic Principle of Hedonic Price Function ($P_h$)

Most previous studies showed that the assumption is true (Michaels and Smith, 1990, Kohlhase, 1991, Ketkar, 1992, and Kiel, 1995, Farber 1998, and Boyle and Kiel, 2001). Michaels and Smith (1990) used the hedonic price model to estimate the impact of hazardous waste sites including 4 NPL sites in Boston on the equilibrium price of the housing market. The study argued that a single hedonic price model would not be adequate to describe the relationship between the housing equilibrium price and different attributes of the homes in a large and complex market and characterized the housing market into different submarkets using submarket definitions provided by local realtors. The study used three variables to estimate the effect of the hazardous waste sites in addition to the structural characteristics of the houses, neighborhood characteristics, and a measure of access to employment areas: the distance between each home and the nearest hazardous waste sites and two qualitative variables for sales in the six months after discovery of the sites and after six months of announcements of hazardous waste sites. The study estimated that the annual benefits from removing the specific hazardous waste sites would be $115/mile for the sample analysis and an average of $139/mile for the submarket analysis.

Kohlhase (1991) analyzed the impacts of toxic waste sites in the Huston area before and after their designation as NPL sites using house sales data in 1976, 1980, and 1985. The study used three types of explanatory variables: structural characteristics of properties, neighborhood characteristics from the census tract, and environmental attributes such as distance between the house and the nearest waste sites. The study found a significant impact of the toxic waste sites on the property value only after announcement of NPL sites. The study also revealed that the house sales price increased by $2,364 for one mile from the NPL sites. The distance effect could be observed up to 6.2 miles from the sites.

Ketkar (1992) analyzed the impact of hazardous waste sites on property values in New Jersey using mainly 1980 Census data. The study employed three types of explanatory variables such as the structural attributes of the properties, the neighborhood attributes including the locational characteristics, and the environmental attributes such as the number of hazardous waste sites in a municipality. The study found that the value of the coefficient of the number of hazardous sites was negative and statistically significant. The study estimated that the median property value would increase by $1,255 if a municipality cleaned up one hazardous waste site.

Kiel (1995) measured the impact of two superfund sites on the property values in a suburb of Boston using the single-family home sales data from 1975 to 1992. The two hazardous waste sites were listed as NPL sites in the early 1980s. The study used proximity to the NPL sites as an environmental attribute in addition to other explanatory variables. The study divided the time period under observation (1975-1992) into six different phases to distinguish the effect of the hazardous waste sites based on the availability of new information on the hazardous waste sites such as EPA's announcement of NPL sites and the cleanup plan. The study revealed that the effects of the hazardous waste sites were negative and statistically significant for all time periods except the first phase when the sites were neither deemed severely harmful by the residents nor listed in the NPL. It was estimated that the property sales prices increased by various amounts ranging from $1,377 to $6,468 during the five periods for one mile increase in the distance of the property from the sites. The empirical study also revealed that the announcement of the cleanup plan and initiation of the cleanup did not lead to a rebound in nearby residential property values due to possible stigma effects.

These studies clearly show that the hazardous waste sites are considered disamenities and the proximity to these sites is negatively related to the property values in the surrounding neighborhoods. While these studies focused on the impact of severely contaminated sites such as NPL sites, some other studies analyzed the impact of small-scale hazardous waste sites, less contaminated sites, or sites that may be perceived as contaminated (Ihlanfeldt and Taylor, 2004, Grigelis, 2005, and Kaufman and Cloutier, 2006). These studies provided meaningful information on the impacts of brownfields on the surrounding neighborhoods since the definition of brownfields includes properties with both actual and perceived contamination and most brownfields are not severely contaminated. In general, these studies revealed that the effects of brownfields would be substantial and statistically significant.

Ihlanfeldt and Taylor (2004) analyzed the effects of small-scale hazardous waste sites on the values of surrounding commercial and industrial properties in Fulton County, Georgia. The study analyzed the effects of the hazardous waste sites both before and after the sites appear on various government lists of hazardous waste sites and tests whether the effects are statistically different from one another. The study categorized the commercial and industrial properties into five different land uses and analyzes separate property price gradients for the properties' proximity to hazardous waste sites. The five land uses included apartment buildings, industrial facilities, office buildings, retail buildings, and vacant land. The study also examined tax increment financing as an option for funding for the cleanup of the hazardous waste sites by comparing the aggregated loss in values of nearby commercial and industrial properties to estimated cleanup costs. The study showed that the sites had negative externality effects on all of five different land-uses both before and after the sites were listed but the effects were statistically significant only after the sites were listed. The study also revealed that the total loss of property value resulting from the contaminated sites could be estimated as large as $1 billion for the entire study area.

Grigelis (2005) investigated how real and perceived contaminated sites affect the value of commercial and industrial properties in Fulton County, Georgia. The study used two sets of hedonic price models to estimate the impact of both real and perceived contaminated properties. For the first set of hedonic models, various governments' lists of hazardous sites were used to analyze the economic impact of sites with known contamination. For the second set of hedonic models, the study developed the probability of contamination model to identify potentially contaminated sites. The probability of contamination model was developed with factors that could affect the investor's perception on the contamination of commercial and industrial properties. The study identified that the negative economic impacts of both actual and perceived contaminated sites on nearby commercial and industrial properties were substantial. According to the study, property value losses resulting from known contamination could be estimated as much as $1.07 billion and estimated losses resulting from perceived contamination could be $663.09 million. The study concluded that significant gains could be expected from the clean-up of the contaminated properties considering the impacts of actual or perceived environmentally contaminated sites on the value of surrounding commercial and industrial properties.

Kaufman and Cloutier (2006) estimated the impacts of both brownfields and green spaces on residential property values in the Lincoln Neighborhood of Kenosha, Wisconsin. The study identified two local brownfields and a neighborhood park to measure the effects of their impact on the property values in the neighborhood. The study formulated two versions of the basic semi-log model since the effects of the environmental amenities and disamenities on a residential property value decrease as distance increases. The study constructed property value gradient functions of residential properties with distance from the brownfields and neighborhood park and found statistically significant impacts of three sites on the residential property value in the neighborhood. The study also estimated the impacts on the residential property values of remediation and redevelopment of two brownfields into green spaces. According to the study, remediation of the brownfields would increase the total value of the 890 residential properties in the neighborhood by between $1.19 and $4.31 million and redevelopment of the sites into green spaces would increase the property values by between $2.40 and $7.01 million.

The studies about the impacts of hazardous waste sites or small scaled brownfields on nearby property values using the hedonic price method show that the disamenity effects of these sites are measurable and significant. Some studies also suggest the importance of public policies regarding remediation and redevelopment of these sites since significant economic benefits would be expected from the remediation or redevelopment of these sites. However, there is another argument that property values may not be fully recovered even though brownfields are cleaned up or redeveloped. Some studies show that even though the negative effects of contaminated sites are substantial and significant, the remediation of these sites does not always lead to a full recovery of the properties' own values or nearby property values due to stigma effects (Patchin, 1991, Kiel, 1995, and McCluskey and Rausser, 2003). There is also an argument that failure to account for the spatial correlation in the hedonic price model overemphasizes the negative impacts of hazardous waste on surrounding property values and inflates benefit estimates of remediation of these sites (Deaton and Hoehn, 2004). Furthermore, some other studies show that the removal of negative externalities is not capitalized into the real estate markets and brownfield remediation or brownfield redevelopment does not always lead to a rebound in property values in surrounding communities (Corona, 2004 and Longo and Alberini, 2005).

Patchin (1991) provided some evidence that property values of known contaminated commercial and industrial properties are not fully recovered after remediation due to stigma effects. He defined the term, stigma as "a loss in value beyond the cost to cure the contamination itself" (p. 167). According to him, stigma has various causes including fear of hidden cleanup cost, the trouble factor, fear of public liability, and the inability to obtain financing. Kiel (1995) also revealed that the announcement and the initiation of cleanup plans did not lead to a rebound in nearby property values due to possible stigma effects as introduced before. McCluskey and Rausser (2003) also pointed out that "both temporary and long-term stigma are possible equilibrium outcomes after the discovery and cleanup of a hazardous waste site" (p. 276). According to them, two externalities contribute to stigma effects: an environmental externality of contaminated sites and a neighborhood externality associated with contaminated sites. In their theoretical model, the environmental externality is the source of temporary stigma and the neighborhood externality results in long-term stigma. The study tested the existence of both temporary and long-term stigma by estimating the impact of a lead smelter on housing sales prices in Dallas County, Texas. The study analyzed the impact of the smelter over four time periods: before identification of health risks, the cleanup stage and the first ruling of completion of cleanup, second ruling of cleanup, and the additional cleanup stage. The study also estimated bid functions for two attributes such as the distance from the smelter site and the level of poverty in order to find empirical supports for long-term stigma caused by the neighborhood externality. The study concluded that long-term stigma existed in a very limited area: within 1.2 mile from the smelter. The study also noted that households from higher-income neighborhoods required a larger discount to live near the remediated hazardous waste sites.

Deaton and Hoehn (2004) showed that standard hedonic procedure that uses a distance variable might overestimate the effect of a hazardous waste site on nearby property values due to omitted variable bias. The study examined two hedonic regression models to estimate the marginal effect of reduced proximity to Superfund sites in Lansing, Michigan. The first regression model omitted a measure of industrial activity while the second model included the variable in the analysis. The results of the first regression model indicates that a 10% increase in distance from a Superfund site increases house prices by 0.32%. The result of the second regression model shows that the distance effect is very low and no longer statistically significant. On the other hand, the effect of the industrial activity variable is similar in size to the distance effect in the first model and statistically significant. The study concluded that failure to account for the spatial correlation overemphasizes the negative impacts of Superfund sites on surrounding property values and inflates benefit estimates of hazardous waste clean-up.

Corona (2004) and Longo and Alberini (2005) further showed that the removal of the negative effects of brownfields is not always capitalized in surrounding real estate markets. Corona (2004), first, estimated the distance effects of brownfield sites on residential properties in Connecticut stemming from proximity to brownfield sites and found that the brownfield distance effect was positive and statistically significant. The study also tested whether surrounding property values are subject to a rebound after the brownfield is redeveloped using seven brownfields that were developed during the study period. The study found that prior to redevelopment the brownfield distance effect was similar to the previous analysis. However, the study suggests that a premium continues to exist for distance from brownfields after redevelopment even though the premium is lower than before. Longo and Alberini (2005) used the hedonic price model to investigate the effects of proximity to contaminated sites and the effects of policies to stimulate growth in neglected areas on the values of commercial and industrial properties in Baltimore, Maryland. The study found that commercial and industrial property values in Baltimore city were virtually unaffected by the proximity to sites either listed on or de-listed from registries of contaminated sites.

The hedonic literature confirms that the existence of brownfields negatively affects the value of surrounding properties. All studies revealed the negative relationship between the proximity to brownfields and surrounding property values. However, the literature does not provide an agreement on whether removal of negative amenities from brownfields can fully or substantially recover the property values in the surrounding community. This study reexamines whether redevelopment of brownfields provides positive impacts on surrounding property values, and thus measures the recovery of surrounding property values. The following chapter discusses in detail the data and empirical models for the study.

# III. STUDY AREA, DATA AND EMPIRICAL MODEL

## 3.1 Study Area

The study area is Lansing, Michigan, which is located in the southern central part of Michigan's Lower Peninsula. Lansing is the sixth largest city in Michigan and located in Ingham County even though a small part of the City is in Eaton County. Lansing, which is the capital of Michigan, contains an estimated total population of 119,128 people and is comprised of an area of 33.8 square miles (U.S. Census Bureau, 2000).

Lansing is a typical urban area suffering from lower socio-economic status as compared to the rest of the State. Table III-1 shows a brief comparison of socio-economic characteristics of the City of Lansing, Ingham County, and the State of Michigan in 1999 and 2007.

Table III-1 Comparison of Selected Socio-economic Characteristics in 1999 and 2007

| Selected Socio-Economic Characteristics | US Census 2000 | | | 2007 Community Survey | | |
|---|---|---|---|---|---|---|
| | Lansing | Ingham | Michigan | Lansing | Ingham | Michigan |
| Total population | 119,128 | 279,320 | 9,938,444 | 118,123 (-0.84%) | 279,295 (-0.01%) | 10,071,822 (1.34%) |
| Median household income ($) | 34,833 | 40,774 | 44,667 | 36,550 (4.93%) | 45,204 (10.86%) | 47,950 (7.35%) |
| % of population with poverty | 16.9 | 14.6 | 10.5 | 23.20 (37.28%) | 18.30 (25.34%) | 14.00 (33.33%) |
| % of unemployed population (16+) | 6.4 | 5.7 | 3.7 | 8.6 (34.38%) | 5.9 (3.51%) | 6.1 (64.86%) |
| % of population (25+) with Bachelor degree or higher | 21.2 | 33 | 21.8 | 24.3 (14.62%) | 35.1 (6.36%) | 24.7 (13.30%) |
| Median Value of Housing ($) | 73,500 | 98,400 | 115,600 | 111,900 (52.24%) | 145,400 (47.76%) | 153,100 (32.33%) |

Source: US Census 2000 and 2007 American Community Survey (U.S. Census Bureau)

In 1999 the median household income in Lansing was $34,833 and 16.9 % of the total population was in poverty while the median household income and the percentage of people below poverty level of the State were $44,667 and 10.5 %, respectively. The median value of owner occupied housing in Lansing was $73,500 while the State's median value of housing was $115,600. The socio-economic characteristics of Lansing were not significantly changed in 2007 as Table III-1 shows. In 2007 the estimated median household income in Lansing was still well below the estimation of the State median household income. These socio-economic indicators show that Lansing is a typical urban area suffering from the flight of the middle class and a deteriorating urban core as compared to the surrounding suburban areas.

As Lansing has experienced a decline in socio-economic conditions, many commercial and industrial properties that once contributed to the local economy began to lose their productivity and were eventually abandoned. In 1999 the City identified 19 brownfield sites, which consume approximately 75 acres of land within its limit (The United States Conference of Mayors, 2000). Besides the City's own identification of the 19 brownfield sites, a state database shows that between 1992 and 2006 Baseline Environmental Assessments (BEAs) were conducted on more than 200 sites (MEDQ, 2007). Since BEAs tend to be conducted for a site that is planned or considered for reuse or redevelopment, the list accounts for only a portion of all brownfields in Lansing, indicating that the number of brownfields is even greater. The presence of many brownfields has reinforced and magnified the problems associated with the declining local economy. However, as the number of BEAs filed in Lansing indicated, there have been ongoing public and private efforts to reuse or redevelop brownfields since Michigan began to implement its voluntary cleanup program progressively by amending the Michigan Environmental Response Act (MERA) as Part 210 of the Natural Resources and Environmental Protection Act known as Public Act 451.

This study analyzed the effects of four brownfield redevelopment cases on property values in surrounding neighborhoods as an attempt to quantify indirect benefits of brownfield redevelopment. The four cases identified by Lansing Economic Development Corporation included Prudden Place Apartments, Motor Wheel Lofts, Neogen Corporation, and Builders Plumbing & Heating Supply. These sites were previously obsolete and blighted properties and successfully redeveloped with public financial assistance between 2004 and 2006. Figure III-1 provides a map that shows the location of the sites.

Prudden Placement Apartments and Motor Wheel Lofts are two different multi-family residential redevelopment projects on a 15-acre former wheel manufacturing site of Motor Wheel. Motor Wheel was founded in 1898 by Georgia-born William Prudden and became the world's largest producer of both wood and steel wheels (Grater Lansing Business Monthly, 2007). Motor Wheel became a subsidiary of Good Tire and Rubber in 1964 and operated the facility in Lansing until 1974. The property was sold to Haynes Wheels in 1974 but was vacated the following year. The property was abandoned until Harry Helper purchased the property in 1998, with plans to develop Motor Wheel Lofts. The western portion of the property was resold to another developer named Pat Gillespie who built Prudden Place Apartments.

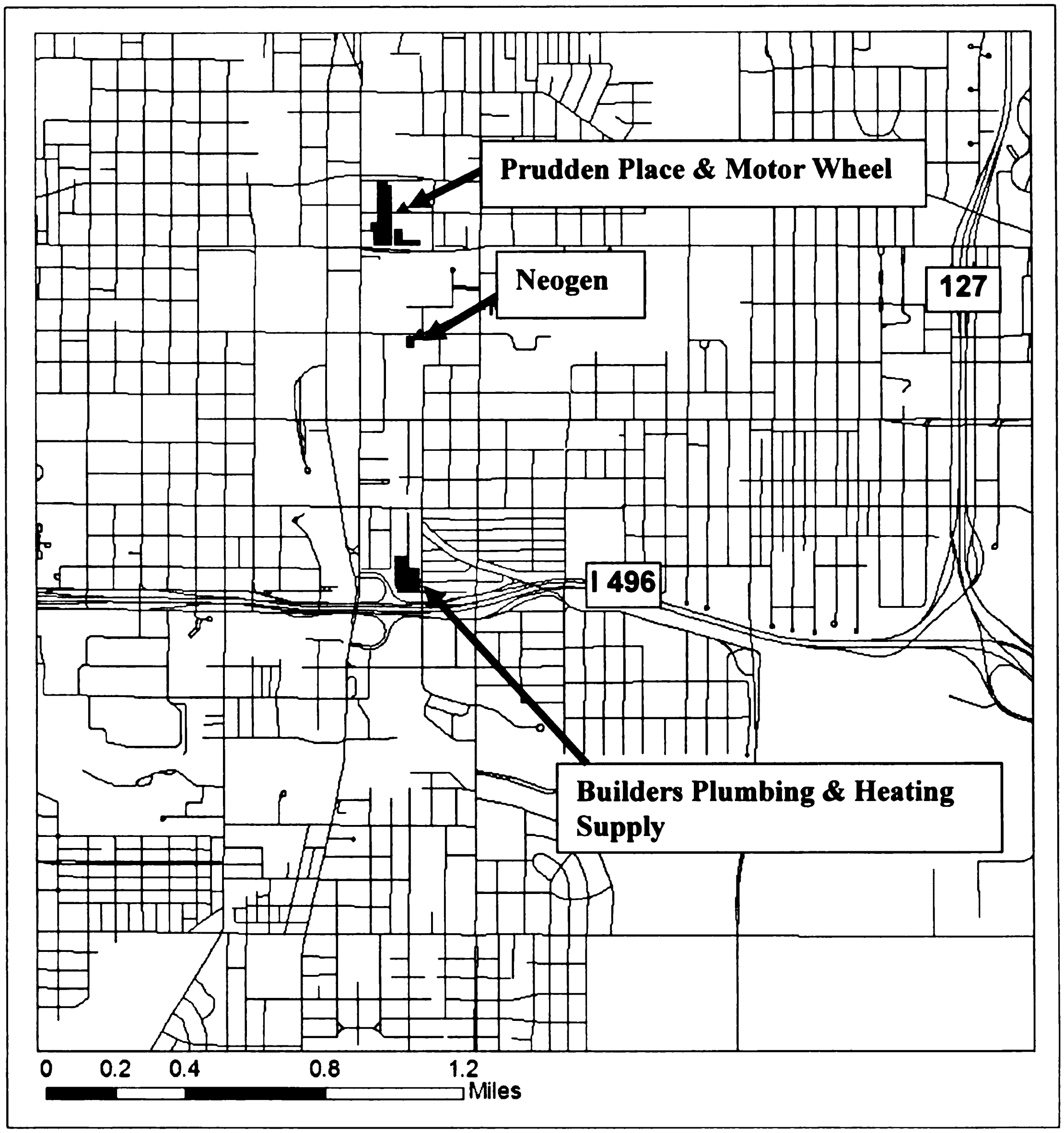


Figure III-1 Location of Brownfields

Motor Wheel Lofts, a 120 unit loft apartment complex, was developed by renovating the historic four-story Prudden Motor Wheel factory in 2005. Prudden Place Apartments is another 120 unit multi-family residential development on the western portion of the Prudden site. The two redevelopment projects were helped and facilitated by many federal and state incentive programs such as the Brownfield Single Business Tax (SBT), Brownfield Tax Inclement Financing, Neighborhood Enterprise Zone credits, and Federal and State Historic Preservation Tax Credits. Figure III-2 shows the picture of the two sites after redevelopment. The two independent brownfield redevelopment projects will be considered as one case for this study since the two projects are located in the same area and have developed in the same time period.

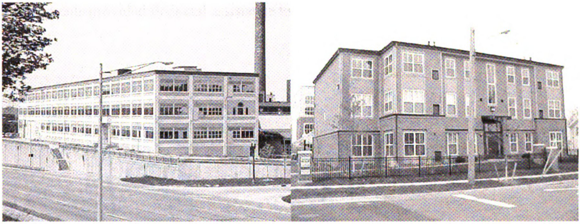

Figure III-2 Motor Wheel Lofts (left) and Prudden Place Apartments (right)
Source: The City of Lansing

Another brownfield redevelopment case for this study is Neogen Corporation. Neogen Corporation, founded in 1982, is a developer and manufacturer of diverse products related to food and animal safety. The Lansing-based company, which has been repeatedly named one of the 200 best small companies in America by *Forbes*, has been expanding its business by acquiring several facilities in Lansing. The company purchased the building on 720 East Shiawassee Street to open its fifth facility in Lansing in 2002.

The old industrial building was renovated in 2003 with support from state and local brownfield financing programs such as the Michigan Brownfield Single Business Tax Credit and the Brownfield Incremental Financing Program. The company also decided to expand and consolidate two out-of-state facilities in Lansing after considering locating the facility at a competing site in Chicago. The company renovated an abandoned building adjacent to its recently renovated building on Shiawassee Street to house the new consolidated manufacturing facility in 2005. The State and City governments provided financial assistance to help the company's expansion project.

Figure III-3 Neogen Corporation
Source: The City of Lansing

The last brownfield redevelopment case examined for this study is an expansion project of Builders Plumbing and Heating Supply near the intersection of Homer and Kalamazoo streets in Lansing. Builders Plumbing and Heating Supply is one of the companies of the Crawford group, which is a wholesale supplier of plumbing and heating products in the Midwest. The company planned the partial demolition of an existing structure and the construction of a new 40,000-square-foot expansion in 2004. The expansion project was completed with financial assistance from the State Brownfield Single Business Tax Credit as well as the City's tax increment financing.

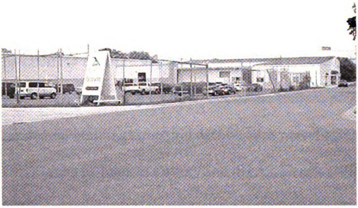

Figure III-4 Builders Plumbing & Heating Supply
Source: The City of Lansing

These brownfield redevelopment projects have helped revitalize the City's economy in addition to bringing the old and obsolete properties into productive use. The availability of financial assistance has leveraged millions of dollars in private investments on these properties, creating new jobs and raising the City's tax base. Motor Wheel Loft created 331 new jobs after attracting about $1.32 million in private investment. Prudden Place Apartments was expected to spur more than $6.5 million in private investment. Neogen Corporation invested about $2 million for the renovation of two buildings and created 42 new jobs. Builders Plumbing and Heating Supply also created 35 high-paying jobs with $1.9 million in private investment.

In addition to the direct impacts of these redevelopment projects, they provide other indirect impacts such as helping revitalize the City, improving the local environment by removing eyesores, and increasing property values in the surrounding neighborhoods. This study measures the indirect impacts of these brownfield redevelopment projects on local property values.

## 3.2 Data

This study collected available data necessary for designing hedonic price functions to measure impacts of brownfield redevelopment projects on the surrounding properties. The primary data source of the study is property transaction data and residential building structural data on each parcel obtained from the Equalization Department of Ingham County and the Assessor's Office of Lansing. The U.S. Census 2000 was another important data source to identify the characteristics of neighborhoods in which each house is located. The digital parcel map and land use map of Lansing was obtained from the Office of Lansing Information and Technology and used to map all house sales data on a GIS (Geographic Information System) map with other attributes that came from the U.S. Census 2000. Building characteristics data were also incorporated into the GIS map in order to determine the distance between each sales observation and the brownfield redevelopment sites.

The property transactions data include all property sales that were registered to the Office of the Ingham County Register of Deeds between 1998 and 2007. This study used only single-family home sales in Lansing and took several elimination processes to exclude recording errors and "non-arms length" sales. First, the study eliminated single family housing transactions that did not use Warranty Deeds as their sales instrument. The eliminated transactions include sales categorized as Quit Claim Deeds, Sherriff's Deeds, Tax Deeds, Court Deeds, etc. The property transactions with these types of transaction instruments are not normally considered as "arms length" sales. The next step was to remove all other sales that were not readily considered as normal sales. The Ingham County property sales data include records and explanations on unusual sales, including transactions between family members, adding a spouse, estate actions, non-profit transactions, etc. The next elimination process gave consideration to missing property attributes. All properties with no sale amount, zero lot size, or no bathroom, were eliminated in this process. After these elimination processes, the study identified 19,489 housing sales from 1998 to 2007 for this hedonic price analysis.

The housing sale observations were further reduced in the process of the hedonic price analysis to minimize the distortion of a hedonic price function. Considering the relatively lower contamination levels of the brownfield sites, negative externalities of the brownfields are assumed to be localized to a relatively small area as Deaton (2002) addressed. This study limited the study area within 1.5 miles from each brownfield site for the hedonic price analysis resulting in 8,458 housing sales observations in the analysis.

The structural data of the buildings obtained from the Equalization Department of Ingham County contains many physical attributes of houses used for the hedonic analysis. The structural attributes include lot size, floor area, garage size, basement area, finished basement area, number of stories, exterior type, etc. The U.S. Census 2000 Summary File 1, 2, 3, 4 produced by the U.S. Census Bureau provided important neighborhood attributes that have been considered as affecting the housing sales price. These additional variables were incorporated with all selected housing sales observations in the digitized parcel map. The ArcINFO, a GIS modeling and mapping software, was used to combine different sets of data into a database as Figure III-5 shows. The GIS map was also used to determine the distance variables between sales observations and each brownfield site. Figure III-6 shows a calculation of the distance variable using the "NEAR" tool of the ArcINFO. Another distance variable between housing observations and the perimeter boundary of the nearest industrial area was also determined using the GIS system. The land use map and parcel map were obtained from the Office of Lansing Information and Technology.

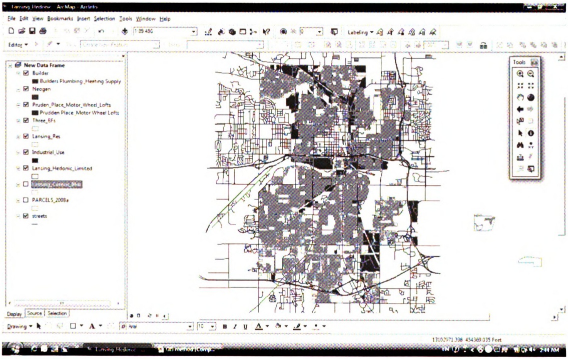


Figure III-5 The Use of a GIS Map to Construct the Database for the Study

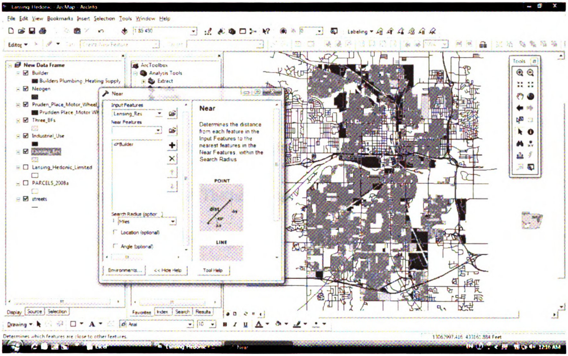


Figure III-6 The Calculation of Distance Variables Using "Near" Tool of the ArcINFO

## 3.3 Empirical Model

In the housing market, there are basically three categories of attributes that affect housing sales prices: structural, neighborhood, and environmental attributes. The structural attributes ($S_i$) are the characteristics that reflect size and other structural qualities of the property itself. The neighborhood attributes ($N_i$) reflect the socio-economic characteristics of the neighborhood where the property is located. Environmental attributes ($E_i$) refer to various site-specific environmental amenities or disamenities that affect the quality of life in the property.

The hedonic price method expresses the *i*th housing price ($P_i$) as a function of these attributes:

$$P_i = P(S_i, N_i, E_i) \quad (3)$$

The literature suggests that there are various functional forms that can be used to explain the relationship between housing prices and proximity to brownfields: the linear function, the quadratic function, the logarithmic function, and the inverse function. In the early stage of the hedonic literature, the linear function was commonly used to explain the relationship. The recent studies preferred to assume other relationships such as an inverse relationship and a log-linear relationship because it could be assumed that the disamenity effects of brownfields decay with distance. However, these functional forms provide interpretative difficulties, as Corona (2004) pointed out.

This study used the linear relationship between housing prices and proximity to brownfields as a base functional form due to its relatively easy interpretation of the coefficient estimates of independent variables. Many previous studies including Wisinger (2006)[11] have also used the linear relationship to measure the impacts of environmental hazards because of the ease of interpretation.

The study also confirmed the linear relationship between housing prices and other independent variables by drawing a scatterplot matrix. Figure III-7 shows the relationship between selected variables. The scatterplot matrix showed a modest linear relationship between these variables exists within a 1.5 mile radius of each brownfield. The scatterplot matrix also showed that a log-linear function can be also used for the hedonic analysis since the natural log of price (*LnPrice*) appeared to be linearly related to the selected independent variables including the distance variable.

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[11] Wisinger (2006) used two functional models for measuring the impact of chemical hazardous sites on residential values: liner and log-linear functional models. This study used the same functional forms as Wisinger's models.

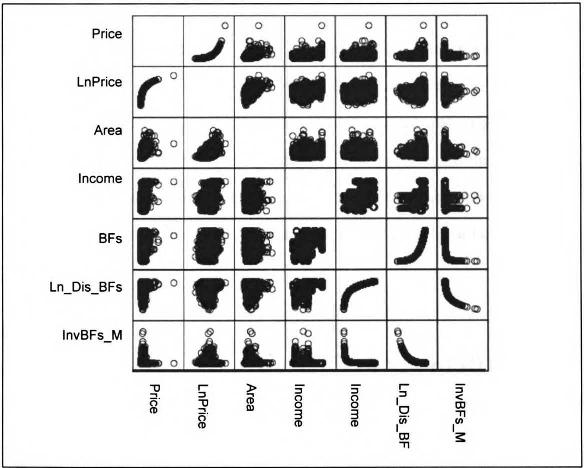


Figure III-7 Scatterplot Matrix for Selected Variables

The study is also limited to sales observations within 1.5 miles from each brownfield site in the hedonic price model since impacts of brownfields were expected to be highly localized. The existing literature shows little guidance in determining the exact point where brownfields have no impact on housing value. According to Deaton (2002), determining the exact point is a judgment call. To determine a reasonable range of impact, Ihlanfeldt and Taylor (2004) continued to expand the assumed impact area surrounding a site using quarter-mile increments until a decline in the precision of the estimated gradients was observed. In their research, this occurred between 1.5 and 2.0 miles for each of the land uses. Grigelis (2005) used the same approach and identified 1.25 ~ 1.5 miles from contaminated sites as a range of impact for different categories of land uses. This study followed the method used by Ihlanfeldt and Taylor to determine the impact area and observed that a decline in the precision of the estimated gradient occurred between 1.5 and 2 miles from brownfield sites. Based on the result, this study assumed that the range of impact of brownfields would be 1.5 miles from each brownfield site.

With the above assumptions, this study used the following linear functional form as a base hedonic model:

$$\begin{aligned} Price_{it} &= \alpha + \sum_{t=1}^{T} b_t D_t + \sum_{j=1}^{J} c_j S_{ij} + \sum_{k=1}^{K} d_k N_{ik} + mIND_i + \\ &\beta_1 Brownfield^B + \beta_2 Brownfield^D + \beta_3 Brownfield^A + e_{it} \end{aligned} \quad (4)$$

where $Price_{it}$ is the sale price of house $i$ at the time of $t$, $\alpha$ is constant, $D_t$ are dummy variables indicating a year when the house was sold, $S_{ij}$ are structural variables of house $i$, $N_{ik}$ are neighborhood variables, and $IND_i$ is the distance between the house $i$ and the nearest industrial area in feet. $Brownfield^B$ is the distance between the house $i$ and brownfields in feet, if the sale occurred before development, otherwise 0. $Brownfield^D$ is the distance between the house $i$ and brownfields in feet, if the sale occurred during the development phase, otherwise 0. $Brownfield^A$ is the distance between the house $i$ and brownfields in feet, if the sale occurred after development, otherwise 0. Finally, $e$ represents a random error.

While the linear functional form is easy to interpret, the log-linear functional form has some advantages over the linear functional form. According to Wooldridge (as cited in Hwang, 2003), the log-linear functional form usually reduces the likelihood of heteroskedasticity, makes estimates less sensitive to outliers by narrowing the range of the dependent variable, and provides two interpretations for the coefficient estimates such as the implicit hedonic price and the percent of the average house price. Because of the advantages from using the log-linear function, this study conducted an additional log-linear functional analysis to compare the overall benefit estimate of the three brownfield redevelopment cases with the results of the linear functional analysis.

For the log-linear functional analysis, all housing sales prices were converted to natural log values ($LnPrice_{it}$). The new hedonic price analysis used the following log-linear functional model:

$$\begin{aligned} Ln\,\mathrm{Pr}ice_{it} &= \alpha + \sum_{t=1}^{T} b_t D_t + \sum_{j=1}^{J} c_j S_{ij} + \sum_{k=1}^{K} d_k N_{ik} + eIND_i + \\ &\beta_1 Brownfield^{B} + \beta_2 Brownfield^{D} + \beta_3 Brownfield^{A} + e_{it} \end{aligned} \tag{5}$$

Table III-2 shows the full set of variables including structural variables $S_i$, the neighborhood variables $N_i$, and two environmental variables $E_i$. In general, the study followed the hedonic price literature in selecting the independent variables, but the availability of data was also an important factor.

Table III-2 Description of Variables for the Hedonic Analysis

| Variable | Description |
|---|---|
| Dependent Variable | |
| *Price* | Housing sales price in 2007 dollars |
| *LnPrice* | The natural log value of *Price* |
| Environmental Variables | |
| *IND* | Distance from each house to the nearest industrial area in feet |
| $Brownfield^{B}$ | Distance (feet) from each house to brownfield site if sale occurred before development, otherwise 0 |
| $Brownfield^{D}$ | Distance (feet) from each house to brownfield site if sale occurred during the development phase, otherwise 0 |
| $Brownfield^{A}$ | Distance (feet) from each house to brownfield site if sale occurred after development, otherwise 0 |
| Housing Structural Variables | |
| *Acre* | Total acreage of the house |
| *Age* | Age of the house when sold |
| *Area* | Total floor area of the house in square feet |
| *Garage* | The total area of garage in square feet |
| *Basement* | The total area of basement in square feet |
| *FINBasement* | The total area of finished basement in square feet |
| *Update* | Dummy variable indicating remodel or update of the property after 1975 |
| *sty1* | Dummy variable indicating 1 story building |
| *sty1.25* | Dummy variable indicating 1 1/4 story building |
| *sty1.5* | Dummy variable indicating 1 1/2 story building |
| *sty1.75* | Dummy variable indicating 1 3/4 story building |
| *sty2* | Dummy variable indicating 2 story building |
| *dumsty* | Dummy variable indicating bi-level, tri-level or 2 1/s story house |
| *alum_vinyl* | Dummy variable indicating the exterior of the house is aluminum or vinyl siding |
| *block_brick* | Dummy variable indicating the exterior of the house is block, brick, stone, or stucco siding |
| *pine_lap* | Dummy variable indicating the exterior of the house is pine/cedar, masonite, or lap siding |
| *Dumexterior* | Dummy variable indicating the exterior of the house is other materials except wood siding |

Table III-2 (cont'd).

| | |
|---|---|
| Neighborhood (Census Block Group) Variables | |
| *Minority1* | Percentage of the population that is African American |
| *Minority2* | Percentage of the population that is Hispanic origin |
| *Income* | Median household income in 1999 dollar |
| *Education* | Percentage of the population 25+ with at least an associate degree |
| *Rent* | Percentage of rental houses in the census tract |
| Sale Years | |
| $D_t$ | Dummy variables indicating the year (1997~2007) when the house was sold |

*Dependent Variables*

The study used *Price* as the dependent variable for the linear functional analysis. *Price* is the sale price of single family housing in Lansing from 1997 to 2007. The housing price was converted to 2007 dollars using the Consumer Price Index (CPI) in order to capture inflation effects in housing prices for each year. The model also included dummy variables ($D_t$) of the sales year as explanatory variables to reflect local trends in the housing market. The study then converted all housing sales prices to natural log values (*LnPrice*) and used it as the dependent variable for the log-linear functional analysis.

*Environmental Variables*

The study included two environmental variables basically: *Brownfield* and *IND*. *Brownfield* is the distance between each house to a brownfield site. Since the study focused on the benefits of brownfield redevelopment, the housing sales observations were divided into three different time phases of brownfield project redevelopment: pre-development, development, and post-development. Several previous studies such as Kohlhase (1991), Kiel (1995), and Dale, et al. (1999) used the same approach to distinguish the effect of the hazardous waste sites based on the different status of the sites such as before and after cleanup. The three variables, $Brownfield^{B}$ , $Brownfield^{D}$ , and $Brownfield^{A}$ represent the distance from each house to a brownfield site if property sale occurs before, during, and after redevelopment of the brownfield, respectively.

This study distinguished the development phase because it can be assumed that the public funding announcement of the development projects and actual development activities may affect the property values of the surrounding neighborhoods. Since all three brownfield sites of this study were named based on the same redevelopment period, the three sites showed the same development time phases. The brownfield sites were not developed in the pre-development phase (1998~2003). Even though the Neogen site was partly remodeled in 2003, its expansion and consolidation project started right after the state government announced its financial support for the project in 2004. Because of this, this study considered 2004 as the beginning of the development phase for this site. In the development time phase (2004~2005), various public financial supports were announced for the development of these sites and various development activities were implemented accordingly.

The study included an additional environmental variable (*IND*), the distance between housing observations and the perimeter boundary of the nearest industrial area to avoid over-estimation of the effect of negative externalities resulting from the existence of other brownfield sites. As Deaton (2002) shows, failure to take into account areas of high industrial activity as well as other potential brownfields will result in inflating the impacts of hazardous sites on the surrounding neighborhood.

### *Housing Structural Variables: Environmental Variables*

In the housing market, the structural attributes are important factors that affect housing sales price. The study used housing structural variables commonly included in hedonic analyses such as the total acreage of the house (*Acre*), the age of the house (*Age*), the total floor area (*Area*), the total area of garage (*Garage*), the total area of basement (*Basement*), and the total area of finished basement (*FINBasement*). The study also included a series of dummy variables indicating remodel or update (*Update*), the story of the house (*sty1, sty1.25, sty1.75, sty2, dumsty*)[12], and the exterior of the house (*alum_vinyl, block_brick, pine_lap, Dumexterior*)[13].

### *Neighborhood Variables*

The neighborhood variables containing socio-economic characteristics are also important factors that affect housing sales price. The study obtained the neighborhood variables from the U.S. Census 2000. These variables include racial composition (*Minority1* and *Minority2*), the median household income (*Income*), the level of education (*Education*), and the percentage of rental houses (*Rent*). These neighborhood variables were obtained from the U.S. Census 2000 Summary File 1, 2, 3, 4 produced by the U.S. Census Bureau.

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12 For the detailed descriptions of the dummy variables, see Table III-2.

13 For the detailed descriptions of the dummy variables, see Table III-2.

This study, first, analyzed all three brownfield sites individually in order to examine the impact of redevelopment of the individual site on surrounding property values by using the base hedonic functional form, the linear functional form. Then, this study combined all three sites in an analysis to assess the aggregated impact of redevelopment of all three sites. Finally, this study conducted an additional log-linear functional analysis to compare the aggregated benefit estimate of the three brownfield redevelopment cases with the result of the linear functional analysis.

The main hypothesis of the study was that the redevelopment of brownfields provides a positive impact on surrounding property values by eliminating or substantially reducing the negative externality associated with each brownfield site. The following chapter shows the empirical estimations of the effects of these brownfield redevelopment projects.

# IV. EMPERICAL RESULTS

## 4.1 Descriptive Summary of Variables

This study is limited to housing sales observations within 1.5 miles from each brownfield site. The completed data set contained a total of 8,458 single-family housing sales that were observed within 1.5 miles from all three sites between 1998 and 2007. As explained in Chapter III, a total of 37 independent variables were identified to explain the housing sales price (*Price*). The housing sales price was adjusted to 2007 dollars using the Consumer Price Index (CPI) and the average sale price was $82,912. The average housing sales price and the average household income of the study area was a bit lower than the City's average housing value and household income described in Chapter III. Table IV-1 shows the summary statistics of all variables in detail.

Table IV-1 Summary of Variables for All Sites (N of observations: 8458)

| Variables | Mean | SD | Minimum | Maximum |
|---|---|---|---|---|
| *Price* | 82912.56 | 37848.798 | 6000 | 500282 |
| *Acre* | .13165 | .062010 | .028 | 1.130 |
| *Age* | 78.10 | 20.204 | 1 | 152 |
| *Area* | 1147.67 | 412.148 | 400 | 5082 |
| *Base* | 682.34 | 241.177 | 0 | 2307 |
| *FINBase* | 58.77 | 159.847 | 0 | 1457 |
| *Garage* | 223.65 | 196.523 | 0 | 1660 |
| *Update* | .02 | .136 | 0 | 1 |
| *Black* | 17.372 | 12.8498 | 3.5 | 66.7 |
| *Hispanic* | 12.48 | 5.685 | 1 | 34 |
| *Rent* | 34.7491 | 17.06897 | 4.57 | 86.82 |
| *Income* | 33423.02 | 9211.719 | 10323 | 60063 |

Table IV-1 (cont'd).

| | | | | |
|---|---|---|---|---|
| *Education* | 29.219 | 14.8873 | 7.3 | 69.2 |
| *STY1* | .39 | .488 | 0 | 1 |
| *STY1.25* | .12 | .319 | 0 | 1 |
| *STY1.5* | .08 | .264 | 0 | 1 |
| *STY1.75* | .10 | .294 | 0 | 1 |
| *STY2.0* | .31 | .465 | 0 | 1 |
| *dumSTY* | .01 | .083 | 0 | 1 |
| *alum_vinyl* | .30 | .457 | 0 | 1 |
| *block_brick* | .02 | .149 | 0 | 1 |
| *pine_lap* | .00 | .043 | 0 | 1 |
| *wood* | .67 | .471 | 0 | 1 |
| *dumexterior* | .01 | .091 | 0 | 1 |
| *dum98* | .09 | .287 | 0 | 1 |
| *dum99* | .10 | .300 | 0 | 1 |
| *dim00* | .10 | .300 | 0 | 1 |
| *dum01* | .10 | .306 | 0 | 1 |
| *dum02* | .11 | .319 | 0 | 1 |
| *dum03* | .11 | .317 | 0 | 1 |
| *dum04* | .12 | .328 | 0 | 1 |
| *dum05* | .11 | .307 | 0 | 1 |
| *dum06* | .09 | .291 | 0 | 1 |
| *dum07* | .06 | .228 | 0 | 1 |
| *Industry* | 1326.9808 | 918.43984 | .00 | 4983.83 |
| *Brownfield* $^B$ | 3189.9175 | 2914.87682 | .00 | 7919.65 |
| *Brownfield* $^D$ | 1161.17 | 2329.618 | 0 | 7918 |
| *Brownfield* $^A$ | 751.13 | 1957.574 | 0 | 7918 |
| *Brownfield*[14] | 5102.2176 | 1951.80243 | 96.86 | 7919.65 |

[14] *Brownfield* variable was not used in the hedonic analysis. Instead distance variables before, during, after development were used to estimate the effects of brownfield during the different time phases.

The study also separated all housing sales observations into three different groups, which were used to assess the effects of individual brownfield sites on the surrounding property values. The mean values of housing price and household income of the Builders group were higher than the other two groups. Table IV-2 provides summary statistics of variables of all three groups.

Table IV-2 Summary of Variables for Individual Sites

| Variables | PRUDDEN (N=5933) | | NEOGEN (N=5345) | | BUILDERS (N=6543) | |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD |
| *Price* | 79975.38 | 38493.55 | 77929.60 | 37604.14 | 81515.86 | 34810.00 |
| *Acre* | .132 | .067 | .126 | .058 | .124 | .053 |
| *Age* | 80.27 | 20.957 | 82.94 | 19.839 | 81.12 | 19.396 |
| *Area* | 1170.13 | 433.758 | 1188.27 | 436.151 | 1172.27 | 416.152 |
| *Base* | 674.61 | 247.452 | 680.21 | 230.625 | 688.94 | 224.227 |
| *FINBase* | 46.41 | 148.468 | 41.22 | 134.016 | 53.77 | 149.723 |
| *Garage* | 217.99 | 201.272 | 203.90 | 198.312 | 212.75 | 193.592 |
| *Update* | .02 | .136 | .02 | .142 | .02 | .141 |
| *Black* | 19.085 | 12.697 | 18.962 | 12.2916 | 16.834 | 12.517 |
| *Hispanic* | 13.95 | 5.915 | 13.71 | 6.041 | 11.62 | 5.398 |
| *Rent* | 38.6999 | 16.01126 | 40.753 | 15.906 | 36.691 | 18.136 |
| *Income* | 31724.32 | 8641.046 | 31160.54 | 8063.546 | 33260.09 | 8526.255 |
| *Education* | 27.427 | 13.5054 | 27.564 | 13.2909 | 30.362 | 14.2917 |
| *STY1* | .35 | .477 | .32 | .466 | .36 | .480 |
| *STY1.25* | .10 | .298 | .09 | .290 | .11 | .310 |
| *STY1.5* | .07 | .259 | .07 | .263 | .08 | .264 |
| *STY1.75* | .11 | .311 | .12 | .323 | .11 | .307 |
| *STY2.0* | .36 | .481 | .39 | .488 | .35 | .476 |
| *dumSTY* | .01 | .088 | .01 | .086 | .01 | .078 |
| *alum_vinyl* | .21 | .410 | .20 | .398 | .30 | .456 |

Table IV-2 (cont'd).

| | | | | | | |
|---|---|---|---|---|---|---|
| *block_brick* | .01 | .111 | .01 | .112 | .02 | .155 |
| *pine_lap* | .00 | .026 | .00 | .027 | .00 | .049 |
| *wood* | .76 | .425 | .78 | .414 | .67 | .471 |
| *dumexterior* | .01 | .092 | .01 | .094 | .01 | .095 |
| *dum98* | .09 | .288 | .09 | .291 | .09 | .291 |
| *dum99* | .10 | .300 | .10 | .301 | .10 | .300 |
| *dim00* | .10 | .297 | .10 | .293 | .10 | .300 |
| *dum01* | .10 | .299 | .10 | .295 | .10 | .306 |
| *dum02* | .11 | .319 | .12 | .321 | .12 | .320 |
| *dum03* | .11 | .317 | .11 | .318 | .11 | .317 |
| *dum04* | .12 | .330 | .13 | .332 | .12 | .327 |
| *dum05* | .11 | .308 | .11 | .309 | .10 | .305 |
| *dum06* | .10 | .293 | .09 | .291 | .09 | .292 |
| *dum07* | .06 | .234 | .06 | .232 | .05 | .224 |
| *Industry* | 1521.850 | 979.982 | 1521.907 | 983.164 | 1326.113 | 899.775 |
| *Brownfield* $^B$ | 3339.74 | 2970.693 | 3345.03 | 2920.405 | 3464.7455 | 3035.155 |
| *Brownfield* $^D$ | 1227.04 | 2406.490 | 1272.09 | 2439.069 | 1257.80 | 2481.261 |
| *Brownfield* $^A$ | 827.09 | 2066.716 | 814.71 | 2037.276 | 800.76 | 2064.967 |
| *Brownfield* | 5393.874 | 1770.476 | 5431.824 | 1609.903 | 5523.30 | 1830.648 |

## 4.2 Results of the Hedonic Price Analysis

The first step in the analysis was to analyze the impact of the redevelopment of individual brownfields on property values in the surrounding neighborhood by using the base hedonic functional form, the linear functional form as stated in Chapter III.

*The Case of Prudden Place Apartments and Motor Wheel Lofts (Prudden)*

For the group of sales observations within 1.5 miles from Prudden Place Apartments and Motor Wheel Lofts (Prudden), the mean distance between all sales observations and Prudden was 5,393.874 ft and the average sales price was $ 79,975 as converted to 2007 US Dollars. As formulated in the empirical hedonic price model, a total of 37 independent variables were used to explain the sales price of single-family housing. Table IV-3 provides the estimated coefficients of the linear hedonic price function.

Table IV-3 Estimated Coefficients (Prudden)

| Variables | B | Sig. |
|---|---|---|
| (Constant) | 45798.555 | .000* |
| *Acre* | 34842.593 | .000* |
| *Age* | -328.242 | .000* |
| *Area* | 32.786 | .000* |
| *Base* | 13.930 | .000* |
| *FINBase* | 18.464 | .000* |
| *Garage* | 19.190 | .000* |
| *Update* | 12853.072 | .000* |
| *Black* | -167.995 | .000* |
| *Hispanic* | -55.445 | .516 |
| *Rent* | -249.361 | .000* |
| *Income* | .209 | .002* |
| *Education* | 631.608 | .000* |
| *STY1* | -5734.537 | .000* |
| *STY1.25* | -2948.795 | .028* |
| *STY1.5* | -132.550 | .923 |

Table IV-3 (cont'd).

| | | |
|---|---|---|
| *STY1.75* | 322.825 | .782 |
| *dumSTY* | -6263.894 | .097** |
| *alum_vinyl* | -1079.134 | .185 |
| *block_brick* | -1606.380 | .584 |
| *pine_lap* | 7992.735 | .519 |
| *dumexterior* | -6408.754 | .068** |
| *dum98* | -39254.313 | .000* |
| *dum99* | -34193.550 | .000* |
| *dum00* | -32192.123 | .000* |
| *dum01* | -21870.819 | .000* |
| *dum02* | -18041.544 | .000* |
| *dum03* | -11094.049 | .000* |
| *dum05* | 2064.431 | .130 |
| *dum06* | -2229.173 | .519 |
| *dum07* | -13539.781 | .000* |
| *Industry* | 2.142 | .000* |
| $Brownfield^{B}$ | 1.816 | .000* |
| $Brownfield^{D}$ | 1.019 | .016* |
| $Brownfield^{A}$ | 1.267 | .013* |
| $Difference^{D-B}$ [15] | -.797 | .069** |
| $Difference^{A-B}$ [16] | -.549 | .290 |
| N=5933 | R square = 0.589 | F= 248.786 |
| Excluded Variables: *STY2, wood, dum04* | | |
| * Statistically significant at the 5% level | | |
| ** Statistically significant at the 10% level | | |

[15] $Difference^{D-B}$ is the difference between $Brownfield^{D}$ and $Brownfield^{B}$. Ihlanfeldt and Taylor (2004) used a dummy variable to measure statistical significance of the difference between the coefficients for two distance variables. This study used their approach to measure the statistical significance of the difference between $Brownfield^{D}$ and $Brownfield^{B}$.

[16] $Difference^{A-B}$ is the difference between $Brownfield^{A}$ and $Brownfield^{B}$

The estimated coefficients of the housing structural variables were consistent with the prior literature. The positive coefficient estimates of lot size (*Acreage*), floor area (*Area*), basement area (*Base*), finished basement area (*FINBase*), and garage area (*Garage*) showed that these variables were positively related to the housing price (*Price*). For example, the estimated coefficient of the floor area indicates that the housing price is expected to go up by $32.786 per a one square foot increase in the floor area, all else constant. The negative sign of the age of house (*Age*) indicates that the age of the house is negatively related to the housing price and the housing price is expected to decrease by $328.242 per a one year increase in the age of the house, holding all else constant. These coefficient estimates were statistically significant at the 5% level.

The estimated coefficients of the neighborhood variables were also consistent with the prior expectations. The percentages of the minority populations (*Black*, *Hispanic*) and the percentage of rental housing units (*Rent*) were negatively related to the housing price (*Price*) while the relationship between the housing price and other two neighborhood variables such as the median household income (*Income*) and the level of education (*Education*) were positive. The coefficient estimates of all neighborhood variables except *Hispanic* were statistically significant at the 5% level.

The negative sign of the coefficient estimate of *Industry* shows that housing price would be lower when a house is located closer to an industrial area. As Deaton (2002) pointed out, proximity to industrial areas affects the benefit estimation of brownfield redevelopment negatively. Omitting this variable would result in an over-estimation of impacts of brownfields on the surrounding property values.

The coefficient estimate of *Brownfield* $^B$ confirmed the previous literature that the proximity to brownfield sites or environmental hazards is negatively related to the property values in nearby neighborhoods. The estimated coefficient of *Brownfield* $^B$ was positive and statistically significant at the 5% level. The positive sign of the coefficient estimate of *Brownfield* $^B$ means that the distance between Prudden and properties within a 1.5 mile radius of Prudden is positively related to the housing price. The housing price was expected to increase by $1.816 as a house was located one foot further away from Prudden, holding all else constant. Conversely, before redevelopment of Prudden, the housing price in the surrounding neighborhood was expected to decrease by $1.816 as its proximity to Prudden was increased by one foot, holding all else constant.

The coefficient estimates of *Brownfield* $^D$ and *Brownfield* $^A$ represent the effects of redevelopment of Prudden on property values in the surrounding neighborhood. Both coefficient estimates were positive and statistically significant at the 5% level, indicating that redevelopment of Prudden did not lead to a full rebound in property values in the surrounding neighborhood. This can be explained by the fact that a portion of the Motor Wheel site still remained undeveloped. Therefore, it is reasonable to expect that the Motor Wheel site still generated negative externalities on residential properties in the surrounding neighborhood. However, the coefficient estimates of both *Brownfield* $^D$ and *Brownfield* $^A$ were lower than the coefficient estimate of *Brownfield* $^B$. Thus, redevelopment of Prudden had a positive impact on housing values in the surrounding neighborhood. Especially, the housing price was affected greatly during the development period. It means that the announcement of the State's financial assistance and the wide publicity of the residential development projects provided a sign that the negative externality associated with Prudden would be eliminated. After redevelopment of Prudden, the housing price was estimated to recover $0.549 or 30% out of the housing value loss of $1.816 per one foot from Prudden.

However, a separate regression analysis showed that the difference between the coefficient estimates of $Brownfield^A$ and $Brownfield^B$ was not statistically significant. In order to determine the difference between the coefficient estimates of $Brownfield^B$, $Brownfield^D$, and $Brownfield^A$, new coefficient estimates of $Difference^{D-B}$ and $Difference^{A-B}$ were determined from a separate regression analysis in which $Brownfield^B$, $Brownfield^D$, and $Brownfield^A$ were combined to form $Brownfield$ (defined as the distance to the brownfield site). The regression analysis estimated $Brownfield$, $Brownfield^D$, and $Brownfield^A$ all together in the model. The coefficient of $Difference^{D-B}$ shows the difference between the coefficients of $Brownfield^D$ and $Brownfield^B$ and was statistically significant at the 10% level. The coefficient of $Difference^{A-B}$ shows the difference between the coefficients of $Brownfield^A$ and $Brownfield^B$ was not statistically significant.

*The Case of Neogen Corporation (Neogen)*

In the case of Neogen Corporation (Neogen), a total of 5,345 housing sales observations entered the hedonic model. The mean distance between all sales observations and Neogen was 5431.824 ft and the average sales price was $ 77,929.6 as converted to 2007 US Dollar. Table IV-4 provides the estimated coefficients of 37 independent variables, which were used to explain housing prices.

Table IV-4 Estimated Coefficients (NEOGEN)

| Variables | B | Sig. |
|---|---|---|
| (Constant) | 45255.137 | .000* |
| *Acre* | 48531.874 | .000* |
| *Age* | -305.497 | .000* |
| *Area* | 30.381 | .000* |
| *Base* | 13.615 | .000* |
| *FINBase* | 19.150 | .000* |
| *Garage* | 17.666 | .000* |
| *Update* | 12657.339 | .000* |
| *Black* | -240.778 | .000* |
| *Hispanic* | -40.023 | .620 |
| *Rent* | -232.876 | .000* |
| *Income* | .112 | .117 |
| *Education* | 665.052 | .000* |
| *STY1* | -6847.707 | .000* |
| *STY1.25* | -2122.386 | .134 |
| *STY1.5* | 895.241 | .525 |
| *STY1.75* | 504.693 | .665 |
| *dumSTY* | -2035.365 | .611 |
| *alum_vinyl* | -2021.958 | .018* |
| *block_brick* | 1133.498 | .709 |
| *pine_lap* | 12185.087 | .320 |
| *dumexterior* | -7891.549 | .027* |
| *dum98* | -37565.647 | .000* |
| *dum99* | -32030.141 | .000* |
| *dum00* | -30512.982 | .000* |
| *dum01* | -21274.617 | .000* |
| *dum02* | -16658.057 | .000* |
| *dum03* | -9343.866 | .002* |

Table IV-4 (cont'd).

| | | |
|---|---|---|
| *dum05* | 3298.492 | .020* |
| *dum06* | -1367.242 | .726 |
| *dum07* | -12052.347 | .003* |
| *Industry* | 2.415 | .000* |
| $Brownfield^{B}$ | 1.810 | .000* |
| $Brownfield^{D}$ | 1.211 | .008* |
| $Brownfield^{A}$ | 1.572 | .005* |
| $Difference^{D-B}$ | -.599 | .234 |
| $Difference^{A-B}$ | -.238 | .686 |
| N=5345 | R square = 0.581 | F= 216.320 |
| Excluded Variables: *STY2, wood, dum04* | | |
| * Statistically significant at the 5% level<br>** Statistically significant at the 10% level | | |

Like Prudden, the estimated coefficients of the housing structural variables and neighborhood variables were consistent with prior expectations. The coefficient estimates of lot size (*Acreage*), floor area (*Area*), basement area (*Base*), finished basement area (*FINBase*), and garage area (*Garage*) were positive and statistically significant at the 5% level, while the estimated coefficient of the age of the house (*Age*) was negative and significant. For the neighborhood variables, the coefficient estimates of the percentage of the minority population (*Black, Hispanic*) and the percentage of rental housing units (*Rent*) were negative, while the household income (*Income*) and the level of education (*Education*) were positive. Among the neighborhood variables were *Income* and *Education* that were not statistically significant at the 10% level. The positive sign of the coefficient estimate of *Industry* suggests that the proximity to the industrial area was negatively related to the housing value.

The coefficient estimates of $Brownfield^{B}$ , $Brownfield^{D}$ , and $Brownfield^{A}$ shows the same pattern as those of Prudden. The estimated coefficient of $Brownfield^{B}$ was positive and significant at the 5% level. Before redevelopment of Neogen, the housing value in the surrounding neighborhood was expected to decrease by $1.81 as its proximity to Neogen increased by one foot, all else constant. Both coefficient estimates of $Brownfield^{D}$ and $Brownfield^{A}$ were positive and statistically significant at the 5% level. Like Prudden, redevelopment of Neogen did not lead to a full rebound in property values in the surrounding neighborhood, which can be explained by the fact that the property still remained in industrial use after redevelopment. As the coefficient estimate of *Industry* shows above, the industrial use of Neogen still negatively affected property values on the surrounding neighborhood.

Nevertheless, redevelopment of Neogen provided positive impacts on housing values in the surrounding neighborhood even though it did not lead to a full recovery of housing values as the coefficient estimates of $Brownfield^{D}$ and $Brownfield^{A}$ show. The coefficient estimates of both $Brownfield^{D}$ and $Brownfield^{A}$ were significantly lower than the coefficient estimate of $Brownfield^{B}$ . Like Prudden, the housing price was affected greatly during the development period. The announcement of the State's financial assistance for the redevelopment project and the publicity of the project played an important role in raising expectations of an increase in housing values resulting from removing the negative externality associated with the Neogen site. After redevelopment of Neogen, the housing value was estimated to recover $0.238 or 13.1% out of the housing value loss of $1.81 per one foot from Neogen. However, a new separate hedonic analysis shows that the difference between the coefficient estimates of $Brownfield^{A}$ and $Brownfield^{B}$ was not statistically significant. The coefficient estimates of both $Difference^{D-B}$ and $Difference^{A-B}$ were not statistically significant.

*The Case of the Builders Plumbing and Heating Supply (Builders)*

For the Builders Plumbing and Heating Supply case (Builders), a total of 6,543 housing sales observations entered the hedonic model. The mean distance between all sales observations and Neogen was 5,523.3 ft and the average sales price was $81,515.86 as converted to 2007 US Dollars. Table IV-5 provides the estimated coefficients of 37 independent variables, which were used to explain the housing price located within 1.5 mile radius of Builders.

The Builders case is a little bit different from the other two redevelopment cases considering the nature of development. The Builders case was an expansion project of the existing use of the property, while the other two projects transformed abandoned sites into the new site uses. It was expected that the difference in the nature of development of Builders would make the pattern of the coefficient estimates of distance variables different from those of the other two cases. The expansion of the existing light industrial use might affect property values in the surrounding neighborhood more negatively while the improvement of the Builders site might provide positive impacts on the surrounding properties.

Table IV-5 Estimated Coefficients (BUILDERS)

| Variables | B | Sig. |
|---|---|---|
| (Constant) | 49410.215 | .000* |
| *Acre* | 46222.489 | .000* |
| *Age* | -292.180 | .000* |
| *Area* | 30.430 | .000* |
| *Base* | 12.790 | .000* |
| *FINBase* | 14.252 | .000* |
| *Garage* | 19.493 | .000* |
| *Update* | 13575.949 | .000* |
| *Black* | -159.759 | .000* |
| *Hispanic* | -552.075 | .000* |
| *Rent* | -225.507 | .000* |
| *Income* | .103 | .097** |
| *Education* | 466.565 | .000* |
| *STY1.25* | 5067.550 | .000* |
| *STY1. 5* | 6468.453 | .000* |
| *STY1.75* | 6188.108 | .000* |
| *STY2* | 5141.655 | .000* |
| *dumSTY* | -5537.072 | .137 |
| *alum_vinyl* | -716.206 | .272 |
| *block_brick* | 4235.545 | .023* |
| *pine_lap* | -1502.035 | .789 |
| *dumexterior* | -5969.166 | .041* |
| *dum98* | -30269.998 | .000* |
| *dum99* | -23951.685 | .000* |
| *dum00* | -22248.254 | .000* |
| *dum01* | -15204.307 | .000* |
| *dum02* | -9041.400 | .000* |
| *dum03* | -2724.464 | .250 |

Table IV-5 (cont'd).

| | | |
|---|---|---|
| *dum05* | 2263.631 | .055** |
| *dum06* | 4002.916 | .176 |
| *dum07* | -5819.920 | .057** |
| *Industry* | .534 | .152 |
| $Brownfield^{B}$ | .991 | .000* |
| $Brownfield^{D}$ | 1.756 | .000* |
| $Brownfield^{A}$ | .832 | .030* |
| $Difference^{D-B}$ | .766 | .042* |
| $Difference^{A-B}$ | -.159 | .704 |
| N=6543 | R square = 0.592 | F= 277.476 |
| Excluded Variables: *STY1, wood, dum04* | | |
| * Statistically significant at the 5% level<br>** Statistically significant at the 10% level | | |

First, as with the two other cases, the estimated coefficients of housing structural variables and neighborhood variables were consistent with prior expectations. The signs of the coefficient estimates of all structural and neighborhoods variables were consistent with the other two cases. The coefficient estimates of the variables were all statistically significant at the 5% level except *Income* variable. The coefficient estimate of *Industry* variable was also consistent with the other two cases, suggesting the proximity to industrial areas was negatively related to housing values.

The coefficient estimates of $Brownfield^{B}$ , $Brownfield^{D}$ , and $Brownfield^{A}$ show the different pattern from those of Prudden and Neogen, as expected. The estimated coefficient of $Brownfield^{B}$ was positive and significant at the 5% level. Before the expansion of Builders, the housing value in the surrounding neighborhood was expected to decrease by $ 0.991 as its proximity to Builders is increased by one foot, holding all else constant. Both coefficient estimates of $Brownfield^{D}$ and $Brownfield^{A}$ were also positive and statistically significant at the 5% level. Like the other two cases, the expansion of Builders did not lead to a full rebound in property values in the surrounding neighborhood. The lack of a full rebound can be explained by the fact that the property still remained as an industrial use after expansion, which still negatively affected property values on the surrounding neighborhood.

The coefficient estimate of $Brownfield^{D}$ was different from those of the two other cases. The coefficient estimate of $Brownfield^{D}$ was higher than the coefficient estimate of $Brownfield^{B}$. This suggests that the expansion of the property for the existing use contributed to more negative externality during the development phase. The construction phase of the project might also affect the surrounding housing values negatively. However, the lower coefficient estimate of $Brownfield^{A}$ suggests that the improvement of the Builders site after development provided positive impacts on the surrounding properties. After the expansion of Builders, the housing value was estimated to recover $0.159 or 16% out of the housing value loss of $ 0.991 per one foot from Builders. However, a new separate hedonic analysis shows that the difference between the coefficient estimates of $Brownfield^{A}$ and $Brownfield^{B}$ was not statistically significant. As seen above, the coefficient estimate of $Difference^{A-B}$ was not statistically significant, while the coefficient estimate of $Difference^{D-B}$ was statistically significant at the 5% level.

*The Overall Impacts of the Three Brownfield Redevelopment Cases*

Finally, this study combined all three groups of data in order to estimate the overall impacts of the three brownfield redevelopment cases. A total of 8,458 sales observations within 1.5 miles from all three sites between 1998 and 2007 were identified for the analysis. Table IV-6 provides the estimated coefficients of 37 independent variables, which were used to explain the housing price.

Table IV-6 Coefficient Estimates (All 3 Brownfield Sites)

| Variables | B | Sig. |
|---|---|---|
| (Constant) | 31406.776 | .000* |
| *Acre* | 32006.452 | .000* |
| *Age* | -328.529 | .000* |
| *Area* | 32.840 | .000* |
| *Base* | 14.701 | .000* |
| *FINBase* | 14.948 | .000* |
| *Garage* | 19.354 | .000* |
| *Update* | 13644.708 | .000* |
| *Black* | -167.270 | .000* |
| *Hispanic* | -79.393 | .237 |
| *Rent* | -141.045 | .000* |
| *Income* | .304 | .000* |
| *Education* | 582.281 | .000* |
| *STY1.25* | 3263.780 | .000* |
| *STY1. 5* | 5567.551 | .000* |
| *STY1.75* | 6312.080 | .000* |
| *STY2* | 5184.351 | .000* |
| *dumSTY* | -1852.983 | .559 |
| *alum_vinyl* | -1621.470 | .006* |

Table IV-6 (cont'd).

| | | |
|---|---|---|
| *block_brick* | 708.062 | .688 |
| *pine_lap* | -3969.895 | .497 |
| *dumexterior* | -5202.279 | .063** |
| *dum98* | -35507.496 | .000* |
| *dum99* | -30224.136 | .000* |
| *dum00* | -28294.259 | .000* |
| *dum01* | -19343.178 | .000* |
| *dum02* | -13936.576 | .000* |
| *dum03* | -7973.187 | .000* |
| *dum05* | 1619.622 | .132 |
| *dum06* | 2164.144 | .369 |
| *dum07* | -7838.495 | .002* |
| *Industry* | 1.261 | .000* |
| $Brownfield^{B}$ | 2.343 | .000* |
| $Brownfield^{D}$ | 2.103 | .000* |
| $Brownfield^{A}$ | 1.242 | .000* |
| $Difference^{D-B}$ | -.240 | .452 |
| $Difference^{A-B}$ | -1.102 | .003* |
| N=8458 | R square = 0.623 | F= 409.107 |
| Excluded Variables: *STY1, wood, dum04* | | |
| * Statistically significant at the 5% level | | |
| ** Statistically significant at the 10% level | | |

The coefficient estimates of the structural and neighborhood variables were consistent with prior expectations as well as all three separate analyses for individual sites. The coefficient estimate of the Industry variable was also consistent with the previous study as well as all three separate analyses. The positive sign of the coefficient estimate of *Industry* suggests that the proximity to the industrial area was negatively related to the housing value.

The coefficient estimates of $Brownfield^{B}$ , $Brownfield^{D}$, and $Brownfield^{A}$ support the hypothesized relationship between proximity to the brownfield sites and housing values. The estimated coefficient of $Brownfield^{B}$ was positive and significant at the 5% level, suggesting that before redevelopment of all three sites, the housing value in the surrounding neighborhood was expected to decrease by $2.343 as its proximity to the nearest brownfield increased by one foot, all else constant. Both coefficient estimates of $Brownfield^{D}$ and $Brownfield^{A}$ were also positive and statistically significant at the 5% level. As shown in the separate analyses, the three sites were still negatively affecting housing values in the surrounding neighborhood. However, the coefficient estimates of both variables were lower than the coefficient estimate of $Brownfield^{B}$ . Redevelopment of these sites had positive impacts on housing values in the surrounding neighborhood. After redevelopment of the three brownfield sites, the housing value was estimated to recover $1.102 or 47.2% out of the housing value loss of $2.343 per one foot from the nearest brownfield site.

Unlike the previous hedonic analyses for individual brownfield sites, a new separate hedonic analysis shows that the difference between the coefficient estimates of $Brownfield^{A}$ and $Brownfield^{B}$ was statistically significant. As seen above, the coefficient estimate of $Difference^{A-B}$ was statistically significant at the 5% level while the coefficient estimate of $Difference^{D-B}$ was not statistically significant. The empirical finding supports the hypothesized relationship between the proximity to brownfield sites and housing values in the surrounding neighborhood before and after redevelopment. Redevelopment of brownfields provides positive impacts on the housing values in the surrounding neighborhood by reducing the negative externality associated with brownfields. The following section will discuss the total benefits of brownfield redevelopment.

## 4.3 Benefit Estimates of Redevelopment

The coefficient estimates of all variables are determinants of housing values as shown in Equation (4).

$$\begin{aligned} Price_{it} = \alpha + \sum_{t=1}^{T} b_t D_t + \sum_{j=1}^{J} c_j S_{ij} + \sum_{k=1}^{K} d_k N_{ik} + mIND_i + \\ \beta_1 Brownfield^B + \beta_2 Brownfield^D + \beta_3 Brownfield^A + e_{it} \end{aligned} \quad (4)$$

The hedonic price functions can be used to predict the expected price of a house both before and after redevelopment of brownfield sites. Since the empirical findings from the hedonic price analyses suggest that redevelopment of brownfields provides positive impacts on housing values in the surrounding neighborhoods, the benefits of redevelopment can be estimated by comparing the expected prices of a house before and after redevelopment. The coefficient estimates of the hedonic function suggest that the change ( $\Delta \hat{P}_i$ ) in the price of the *i*th house can be estimated with the following equation:

$$\Delta \hat{P}_i = \hat{P}_i^A - \hat{P}_i^B = (\beta_3 - \beta_1) Brownfield_i$$
$$= (Difference^{A-B}) Brownfield_i \qquad (6)$$

Since the coefficient estimates of all structural, neighborhood variables, dummy variables, and the proximity to industrial areas were the same regardless of different phases of redevelopment, the coefficient estimates ($\beta_1$, ($\beta_3$) of $Brownfield^B$ and $Brownfield^A$ will determine the change in the housing value before and after redevelopment of brownfield sites. The price change equals the difference in the coefficient estimates for $Brownfield^B$ and $Brownfield^A$, weighted by the distance of house *i* to the brownfield site as shown in Equation (6). Based on Equation (6), the total impact of brownfield redevelopment can be estimated with the following equation:

$$\Delta \hat{P} = (\beta_3 - \beta_1) Mean\_Brownfield * Num =$$
$$(Difference^{A-B}) Mean\_Brownfield * Num \qquad (7)$$

where $Mean\_Brownfield$ is the mean distance between all houses and the brownfield site and $Num$ is the number of all single family housing within 1.5 mile radius of the brownfield site. In Equation (7), $\Delta \hat{P}$ represents the total estimation of the change in property value loss in the neighborhood since the coefficient estimate of $Brownfield^B$ represents the estimated decrease in housing prices as proximity to Prudden is increased by one foot, all else constant. Table IV-7 summarizes the coefficient estimates of *Difference*$^{A-B}$ for all four hedonic price functions in this study.

Table IV-7 The Coefficient Estimates of *Difference*$^{A-B}$

| | Prudden | | Neogen | | Builders | | All Sites | |
|---|---|---|---|---|---|---|---|---|
| Variable | B | Sig | B | Sig | B | Sig | B | Sig |
| *Brownfield*$^{B}$ | 1.816 | .000* | 1.810 | .000* | .991 | .000* | 2.343 | .000* |
| *Brownfield*$^{A}$ | 1.267 | .013* | 1.572 | .005* | .832 | .030* | 1.242 | .000* |
| *Difference*$^{A-B}$ | -.549 | .290 | -.238 | .686 | -.159 | .704 | -1.102 | .003* |

* Statistically significant at the 5% level
** Statistically significant at the 10% level

In this study, benefit estimates were derived for all houses within a 1.5 mile radius of the brownfield site as the study was conducted under an assumption that the negative externality associated with brownfield sites is expected to affect the property values within 1.5 miles from the brownfield sites.

Table IV-8 shows the number of properties affected by the existence or redevelopment of brownfields and the mean distance between all properties and the brownfield site for all four hedonic price functions of this study. The table also provides the benefit estimations for redevelopment of individual brownfield sites and the estimation of aggregate benefits resulting from redevelopment of all three brownfield sites.

Table IV-8 Benefit Estimates of Redevelopment of Brownfield Sites

| Variable | Prudden | Neogen | Builders | All Sites |
|---|---|---|---|---|
| $Difference^{A-B}$<br>(Sig) | -.549<br>(.290) | -.238<br>(.686) | -.159<br>(.704) | -1.102<br>(.003)* |
| N of Properties | 11,526 | 10,469 | 11,939 | 15,761 |
| Mean Distance | 5,256.291 | 5,377.224 | 5,438.146 | 4,949.304 |
| Estimated Benefits | 33,260,622 | 13,398,010 | 10,323,238 | 85,962,590 |

The benefit estimates of redevelopment of Prudden, Neogen, and Builders were approximately $33,260,622, $13,398,010, and $10,323,238 respectively. The study may compare the benefit estimates of brownfield redevelopment based on different redevelopment scenarios since the three cases represent different redevelopment scenarios such as a multi-family residential development for Prudden, renovation of an old industrial building for Neogen, and expansion of a warehouse for Builders. According to the study, the multi-family residential redevelopment generated the greatest benefit while the expansion of the warehouse provided the least amount of benefit. However, this comparison cannot be generalized due to the limited number of brownfield redevelopment cases of the study.

In addition, the study could not conclude that the benefit estimates of these individual brownfield redevelopment projects were statistically meaningful because the coefficient of $Difference^{A-B}$ was not statistically significant for all individual brownfield cases. However, the coefficient of $Difference^{A-B}$ for all sites was statistically significant at the 5% level and thus the study was able to provide a meaningful estimation of the overall benefits of the redevelopment of all three brownfield sites. The estimation of aggregate indirect benefits of the three brownfield redevelopment projects was approximately $85,962,590 in addition to the direct benefits of these projects.

## 4.4 Comparison with a Semi-Log Functional Analysis

The linear functional analysis shows that the estimation of indirect benefits of the three brownfield redevelopment projects was substantial. However, according to Figure III-7, the natural log of price ($LnPrice_{it}$) was also appeared to be linearly related to the distance variable, a log-linear function could be also used for assessing the impacts of brownfield redevelopment. The log-linear functional form has some advantages over the linear functional form as explained in Chapter III.

Because of the advantages from using the log-linear function, this study conducted an additional log-linear functional analysis to compare the overall benefit estimate of the three brownfield redevelopment cases with the result of the linear functional analysis. For the log-linear functional analysis, all housing sales prices were converted to natural log values ($LnPrice_{it}$). The new hedonic price analysis used the following log-linear functional model:

$$Ln\,\mathrm{Pr}ice_{it} = \alpha + \sum_{t=1}^{T} b_t D_t + \sum_{j=1}^{J} c_j S_{ij} + \sum_{k=1}^{K} d_k N_{ik} + eIND_i + \beta_1 Brownfield^B + \beta_2 Brownfield^D + \beta_3 Brownfield^A + e_{it} \quad (5)$$

The coefficient estimates[17] of the structural and neighborhood variables were consistent with the results of the linear functional analysis, showing the same signs of the independent variables. Table IV-9 presents the summary results of the log-linear model in comparison with the results of the linear functional model.

Table IV-9 Results of the Linear Functional & the Log-Linear Functional Analyses

| | Log-Linear Functional Analysis F=317.055 R square = 0.554 | | Linear Functional Analysis F= 409.107 R square = 0.623 | |
|---|---|---|---|---|
| Variable | B | B | B | Sig |
| *Brownfield*$^{B}$ | 4.031E-5 | .000* | 2.343 | .000* |
| *Brownfield*$^{D}$ | 2.017E-5 | .000* | 2.103 | .000* |
| *Brownfield*$^{A}$ | 1.856E-5 | .000* | 1.242 | .000* |
| *Difference*$^{D-B}$ | -2.015E-5 | .000* | -.240 | .452 |
| *Difference*$^{A-B}$ | -2.176E-5 | .000* | -1.102 | .003* |
| *Difference*$^{A-B}$ | | -2.176E-5 | | -1.102 |
| Transformation | | -1.000022 | | |
| N of Properties | | 15,761 | | 15,761 |
| Mean Distance | | 4,949.304 | | 4,949.304 |
| Estimated Benefits | | $78,007,696 | | $85,962,590 |

* Statistically significant at the 5% level
** Statistically significant at the 10% level

The coefficient estimates of *Brownfield*$^{B}$, *Brownfield*$^{D}$, and *Brownfield*$^{A}$ in the log-linear model had the expected signs and are statistically significant at the 1% level. The coefficient estimate of *Brownfield*$^{A}$ was lower than the coefficient estimate of

[17] For the result of the log-linear functional analysis, see Appendix E.

*Brownfield*$^{B}$, indicating that redevelopment of the three brownfield sites had positive impacts on housing values in the surrounding neighborhood. The difference (*Difference*$^{A-B}$) between the coefficient estimates of *Brownfield*$^{B}$ and *Brownfield*$^{A}$ was statistically significant at the 1% level.

In order to determine the benefits of the redevelopment of three brownfields, the natural log value of the coefficient estimate of *Difference*$^{A-B}$ was converted to the original normal value using the following procedure.

$$\ln(x) = 0.00002176$$

$$x = e^{0.00002176} = 1.000022$$

The natural value of the coefficient estimate of *Difference*$^{A-B}$ in the log-linear model was slightly lower than the coefficient estimate of the same variable in the linear functional model, resulting in a slightly lower estimated benefit of redevelopment. The benefit estimated by the log-linear model was $78,007,696. Even though the estimated benefit was a bit different, the results of the log-linear model analysis were almost similar to the results of the linear model analysis. The values of R square of both functional analyses show that the linear model better explained the variation in housing values than the log-linear model.

# V. CONCLUSION

The main purpose of this study was to assess the indirect benefits of brownfield redevelopment by using the hedonic price method. The hedonic price method has been widely used to measure environmental goods and services that cannot be assessed in the existing market system. The hedonic price method uses the changes in complementary goods such as housing to assess a willingness to pay for an improved environment. The existing literature measured the negative impacts of brownfields on property values in the surrounding neighborhood as an attempt to measure the benefits of brownfield redevelopment. Many studies hypothesized that the existence of brownfields could be considered disamenity factors to the surrounding properties. These studies revealed that the proximity to brownfields is negatively related to nearby property values. The previous studies further assumed that the negative externality associated with brownfields would be eliminated after cleanup or redevelopment of brownfields, concluding that the negative impacts of the existence of brownfields on the surrounding property values would become the expected benefits of cleanup or redevelopment of brownfields. However, the existing literature does not provide an agreement on whether the cleanup or redevelopment of brownfields can fully or substantially recover the loss of property values in the surrounding neighborhood.

## 5.1 Summary of Findings

This study attempted to analyze the impacts of brownfield redevelopment on the surrounding properties, using three brownfield redevelopment cases in Lansing, Michigan. The study constructed hedonic functions to explain housing values with housing structural variables, neighborhood variables, and two environmental variables. One environmental variable measured the negative externality associated with proximity to industrial areas. The main environmental variable was the distance between housing observations and brownfield sites. The distance variable was constructed to help measure the impacts of brownfields on the surrounding property values before, during, and after redevelopment.

The empirical findings of the hedonic price analysis confirmed findings from the existing literature arguing that the proximity to brownfield sites or environmental hazards is negatively related to the property values in nearby neighborhoods. Before the redevelopment of brownfields, the proximity to the brownfield sites and housing prices were negatively related to each other. The negative relationship between the proximity and housing prices suggests that there was a substantial loss in property values in the surrounding neighborhood due to the negative externality associated with brownfields. Redevelopment of brownfields was expected to eliminate such negative externality and lead to recovering the loss of property values.

This study was able to analyze the effects of brownfield redevelopment on the surrounding property values. The empirical findings of the analyses support the hypothesized relationship between the proximity to brownfield sites and housing values in the surrounding neighborhood before and after redevelopment. Redevelopment of brownfields was expected to provide positive impacts on the housing values in the surrounding neighborhood by eliminating or substantially reducing the negative externality associated with brownfields. Even though the difference between the coefficient estimates of the distance variables before and after redevelopment were not statistically significant for all individual brownfield redevelopment projects, the coefficient estimate of the distance variable after redevelopment was consistently lower than the coefficient estimate of the distance variable before redevelopment. The lower coefficient suggests that the redevelopment of individual brownfields may have positive impacts on the nearby surrounding property values, but the analyses could not conclude that it is statistically meaningful.

The study was also able to compare the benefit estimates of brownfield redevelopment based on different redevelopment scenarios. The three cases represent different redevelopment scenarios such as a multi-family residential development, renovation of an old industrial building, and expansion of a warehouse. The empirical findings of the study suggest that the multi-family residential redevelopment generated the greatest benefit while the expansion of the warehouse provided the least amount of benefit. However, this comparison cannot be generalized due to the limited number of brownfield redevelopment cases in the study.

Finally, the final analysis that estimated the overall impact of three brownfield redevelopment projects provided statistically meaningful results on the impacts of brownfield redevelopment on the surrounding property values. The analysis showed that the difference between the coefficient estimates of the distance variables before and after redevelopment were statistically significant at the 5% level for combined brownfield redevelopment projects. It was estimated that redevelopment of the three brownfield sites provided a total benefit of $85,962,590 ($78,007,696 if the log-linear function was applied) in addition to the direct benefit of the projects such as the number of jobs created or an increase in the tax base after redevelopment.

## 5.2 Policy Implications of the Study

Brownfield redevelopment has been an important policy for the federal and state governments. Due to several barriers associated with cleanup or reuse of brownfields such as liability and additional costs, aggressive public financing and other technical assistance are necessary to facilitate brownfield redevelopment. Federal and state governments have responded very actively to these challenges by providing a variety of financial and technical assistance programs to promote cleanup and redevelopment of brownfields. Due to support from governments, a large number of brownfield sites have been converted to productive uses throughout the U.S. Many studies reported economic benefits of brownfield cleanup and redevelopment by using a set of indicators such as the number of jobs created, increased income, increased tax revenues generated by newly redeveloped sites, etc. However, these studies did not successfully report all the possible benefits of brownfield redevelopment because some environmental and social benefits were not easy to quantify.

The study analyzed impacts of brownfield redevelopment on the price of surrounding properties in order to quantify the indirect benefits of brownfield redevelopment using three brownfield redevelopment cases in Lansing, Michigan. Redevelopment of brownfields was expected to provide positive impacts on the housing values in the surrounding neighborhood by eliminating or substantially reducing the negative externality associated with brownfields.

As this study confirms, the cleanup or redevelopment of brownfields provides indirect benefits that cannot be measured easily in the current market system. However, this kind of indirect benefit of brownfield redevelopment has not been an important consideration in the public decision-making framework. Without acknowledgement of the full potential benefits and costs associated with brownfield redevelopment, it is not possible to make an efficient allocation of resources in the public policy area. The empirical findings of this study can justify public financial assistance for the cleanup or redevelopment of brownfields. The findings can also help government officials prioritize competing projects to use public resources more efficiently. This study suggests that the estimated hedonic function can be used to determine the benefits of brownfield cleanup or redevelopment in the decision-making process.

## 5.3 Limitations and Recommendations

Even with its meaningful empirical findings, this study contained certain limitations. First, since this study used a small number of brownfield redevelopment cases in a single geographical location, its empirical findings cannot be generalized and can only represent the impacts of three brownfield redevelopment projects in Lansing, MI. In addition, even though the study compared the benefits of three brownfield redevelopment cases based on their different redevelopment scenarios, the comparison should not be generalized due to the limited number of brownfield redevelopment cases in the study. The limitations of the study suggest that future researchers might consider analyzing the indirect economic impacts of brownfield redevelopment using a large number of redeveloped brownfields in various geographical locations.

Second, even though the values of R-square of the hedonic price analyses of this study were higher than those of other hedonic studies in general, the values were still a bit lower to explain the variations in housing prices. One of the reasons might be that the modified housing transaction data still contained "non-arms length" sales even though the study undertook several procedures to eliminate these cases. This suggests that more accurate housing market data is necessary for improving the ability to explain variations in values of a dependent variable.

Third, the disparity between the numbers of housing sales observations before and after redevelopment might affect the level of statistical significance of the estimated benefits after redevelopment of individual brownfield redevelopment projects. If time permits, balancing the number of sales observations before and after redevelopment will improve the level of statistical significance.

While this study is generally consistent with findings form other hedonic price studies on the impact of amenities and disamenities, the findings of this study also need to be compared to other non-hedonic method approaches to value one's willingness to pay for brownfield redevelopment projects.

# APPENDICES

## APPENDIX A Regression Analysis for PRUDDEN

**Descriptive Statistics**

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Price | 5933 | 6000 | 500282 | 79975.38 | 38493.551 |
| Acre | 5933 | .028 | 1.130 | .13243 | .066860 |
| Age | 5933 | 1 | 152 | 80.27 | 20.957 |
| Area | 5933 | 400 | 5082 | 1170.13 | 433.758 |
| Base | 5933 | 0 | 2307 | 674.61 | 247.452 |
| FINBase | 5933 | 0 | 1457 | 46.41 | 148.468 |
| Garage | 5933 | 0 | 1660 | 217.99 | 201.272 |
| Update | 5933 | 0 | 1 | .02 | .136 |
| Black | 5933 | 3.9 | 66.7 | 19.085 | 12.6971 |
| Hispanic | 5933 | 4.3 | 33.8 | 13.952 | 5.9145 |
| Rent | 5933 | 13.70 | 86.82 | 38.6999 | 16.01126 |
| Income | 5933 | 10323 | 57768 | 31724.32 | 8641.046 |
| Education | 5933 | 8.7 | 58.3 | 27.427 | 13.5054 |
| Poverty | 5933 | 4.51 | 53.77 | 22.5444 | 11.06829 |
| STY1 | 5933 | 0 | 1 | .35 | .477 |
| STY1.25 | 5933 | 0 | 1 | .10 | .298 |
| STY1.5 | 5933 | 0 | 1 | .07 | .259 |
| STY1.75 | 5933 | 0 | 1 | .11 | .311 |
| STY2 | 5933 | 0 | 1 | .36 | .481 |
| dumSTY | 5933 | 0 | 1 | .01 | .088 |
| alum_vinyl | 5933 | 0 | 1 | .21 | .410 |
| block_brick | 5933 | 0 | 1 | .01 | .111 |
| pine_lap | 5933 | 0 | 1 | .00 | .026 |
| wood | 5933 | 0 | 1 | .76 | .425 |
| dumexterior | 5933 | 0 | 1 | .01 | .092 |
| dum98 | 5933 | 0 | 1 | .09 | .288 |
| dum99 | 5933 | 0 | 1 | .10 | .300 |
| dim00 | 5933 | 0 | 1 | .10 | .297 |
| dum01 | 5933 | 0 | 1 | .10 | .299 |

Descriptive Statistics (cont'd)

| | | | | | |
|---|---|---|---|---|---|
| dum02 | 5933 | 0 | 1 | .11 | .319 |
| dum03 | 5933 | 0 | 1 | .11 | .317 |
| dum04 | 5933 | 0 | 1 | .12 | .330 |
| dum05 | 5933 | 0 | 1 | .11 | .308 |
| dum06 | 5933 | 0 | 1 | .10 | .293 |
| dum07 | 5933 | 0 | 1 | .06 | .234 |
| Industry | 5933 | .00 | 4983.83 | 1521.8504 | 979.98223 |
| Dis_PRU_B | 5933 | 0 | 7920 | 3339.74 | 2970.693 |
| Dis_PRU_D | 5933 | 0 | 7918 | 1227.04 | 2406.490 |
| Dis_PRU_A | 5933 | 0 | 7918 | 827.09 | 2066.716 |
| PRU | 5933 | 291.71 | 7919.65 | 5393.8738 | 1770.47550 |
| Valid N (listwise) | 5933 | | | | |

**Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .768 | .589 | .587 | 24743.476 |

a. Predictors: (Constant), Dis_PRU_A, Education, STY1.5, block_brick, pine_lap, dumSTY, Update, dumexterior, Acre, STY1.25, dim00, STY1.75, FINBase, dum98, alum_vinyl, dum01, dum99, Rent, Garage, dum03, Base, dum05, Black, Industry, dum07, Age, dum02, STY1, Hispanic, Area, Income, Dis_PRU_D, Dis_PRU_B, dum06

**ANOVA**

| Model | | Sum of Squares | df | Mean Square | F |
|---|---|---|---|---|---|
| 1 | Regression | 5.179E12 | 34 | 1.523E11 | 248.786 |
| | Residual | 3.611E12 | 5898 | 6.122E8 | |
| | Total | 8.790E12 | 5932 | | |

a. Predictors: (Constant), Dis_PRU_A, Education, STY1.5, block_brick, pine_lap, dumSTY, Update, dumexterior, Acre, STY1.25, dim00, STY1.75, FINBase, dum98, alum_vinyl, dum01, dum99, Rent, Garage, dum03, Base, dum05, Black, Industry, dum07, Age, dum02, STY1, Hispanic, Area, Income, Dis_PRU_D, Dis_PRU_B, dum06

b. Dependent Variable: Price

**Coefficients**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 45798.555 | 4887.076 | | 9.371 | .000 |
| | Acre | 34842.593 | 5386.019 | .061 | 6.469 | .000 |
| | Age | -328.242 | 20.537 | -.179 | -15.983 | .000 |
| | Area | 32.786 | 1.227 | .369 | 26.727 | .000 |
| | Base | 13.930 | 1.632 | .090 | 8.538 | .000 |
| | FINBase | 18.464 | 2.313 | .071 | 7.983 | .000 |
| | Garage | 19.190 | 1.728 | .100 | 11.107 | .000 |
| | Update | 12853.072 | 2419.895 | .045 | 5.311 | .000 |
| | Black | -167.995 | 34.313 | -.055 | -4.896 | .000 |
| | Hispanic | -55.445 | 85.410 | -.009 | -.649 | .516 |
| | Rent | -249.361 | 36.894 | -.104 | -6.759 | .000 |
| | Income | .209 | .068 | .047 | 3.068 | .002 |
| | Education | 631.608 | 43.199 | .222 | 14.621 | .000 |
| | STY1 | -5734.537 | 1037.460 | -.071 | -5.527 | .000 |
| | STY1.25 | -2948.795 | 1343.612 | -.023 | -2.195 | .028 |
| | STY1.5 | -132.550 | 1379.547 | .000 | -.096 | .923 |
| | STY1.75 | 322.825 | 1166.649 | .003 | .277 | .782 |
| | dumSTY | -6263.894 | 3775.494 | -.014 | -1.659 | .097 |
| | alum_vinyl | -1079.134 | 814.832 | -.012 | -1.324 | .185 |
| | block_brick | -1606.380 | 2933.253 | -.005 | -.548 | .584 |
| | pine_lap | 7992.735 | 12401.171 | .005 | .645 | .519 |
| | dumexterior | -6408.754 | 3510.007 | -.015 | -1.826 | .068 |
| | dum98 | -39254.313 | 2717.984 | -.294 | -14.442 | .000 |
| | dum99 | -34193.550 | 2727.301 | -.266 | -12.538 | .000 |
| | dim00 | -32192.123 | 2717.207 | -.249 | -11.848 | .000 |
| | dum01 | -21870.819 | 2727.976 | -.170 | -8.017 | .000 |
| | dum02 | -18041.544 | 2689.644 | -.150 | -6.708 | .000 |
| | dum03 | -11094.049 | 2690.129 | -.091 | -4.124 | .000 |
| | dum05 | 2064.431 | 1361.559 | .017 | 1.516 | .130 |
| | dum06 | -2229.173 | 3457.755 | -.017 | -.645 | .519 |
| | dum07 | -13539.781 | 3595.244 | -.082 | -3.766 | .000 |

Coefficients (cont'd).

| | | | | | | |
|---|---|---|---|---|---|---|
| | Industry | 2.142 | .411 | .055 | 5.207 | .000 |
| | Dis_PRU_B | 1.816 | .310 | .140 | 5.867 | .000 |
| | Dis_PRU_D | 1.019 | .425 | .064 | 2.399 | .016 |
| | Dis_PRU_A | 1.267 | .509 | .068 | 2.487 | .013 |

a. Dependent Variable: Price

**Excluded Variables**

| Model | | Beta In | t | Sig. | Partial Correlation | Collinearity Statistics |
|---|---|---|---|---|---|---|
| | | | | | | Tolerance |
| | STY2 | .[a] | . | . | . | .000 |
| | wood | .[a] | . | . | . | .000 |
| | dum04 | .[a] | . | . | . | .000 |

a. Predictors in the Model: (Constant), Dis_PRU_A, Education, STY1.5, block_brick, pine_lap, dumSTY, Update, dumexterior, Acre, STY1.25, dim00, STY1.75, FINBase, dum98, alum_vinyl, dum01, dum99, Rent, Garage, dum03, Base, dum05, Black, Industry, dum07, Age, dum02, STY1, Hispanic, Area, Income, Dis_PRU_D, Dis_PRU_B, dum06

b. Dependent Variable: Price

## APPENDIX B Regression Analysis for NEOGEN

**Descriptive Statistics**

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Price | 5345 | 6000 | 500282 | 77929.60 | 37604.138 |
| Acre | 5345 | .028 | 1.130 | .12579 | .058433 |
| Age | 5345 | 1 | 152 | 82.94 | 19.839 |
| Area | 5345 | 400 | 5082 | 1188.27 | 436.151 |
| Base | 5345 | 0 | 2307 | 680.21 | 230.625 |
| FINBase | 5345 | 0 | 1338 | 41.22 | 134.016 |
| Garage | 5345 | 0 | 1660 | 203.90 | 198.312 |
| Update | 5345 | 0 | 1 | .02 | .142 |
| Black | 5345 | 3.9 | 66.7 | 18.962 | 12.2916 |
| Hispanic | 5345 | 3.8 | 33.8 | 13.708 | 6.0406 |
| Rent | 5345 | 4.57 | 86.82 | 40.7530 | 15.90551 |
| Income | 5345 | 10323 | 59904 | 31160.54 | 8063.546 |
| Education | 5345 | 7.3 | 69.2 | 27.564 | 13.2909 |
| Poverty | 5345 | 1.25 | 53.77 | 23.2125 | 10.53755 |
| STY1 | 5345 | 0 | 1 | .32 | .466 |
| STY1.25 | 5345 | 0 | 1 | .09 | .290 |
| STY1.5 | 5345 | 0 | 1 | .07 | .263 |
| STY1.75 | 5345 | 0 | 1 | .12 | .323 |
| STY2 | 5345 | 0 | 1 | .39 | .488 |
| dumSTY | 5345 | 0 | 1 | .01 | .086 |
| alum_vinyl | 5345 | 0 | 1 | .20 | .398 |
| block_brick | 5345 | 0 | 1 | .01 | .112 |
| pine_lap | 5345 | 0 | 1 | .00 | .027 |
| wood | 5345 | 0 | 1 | .78 | .414 |
| dumexterior | 5345 | 0 | 1 | .01 | .094 |
| dum98 | 5345 | 0 | 1 | .09 | .291 |
| dum99 | 5345 | 0 | 1 | .10 | .301 |
| dim00 | 5345 | 0 | 1 | .10 | .293 |
| dum01 | 5345 | 0 | 1 | .10 | .295 |
| dum02 | 5345 | 0 | 1 | .12 | .321 |

Descriptive Statistics (cont'd)

| | | | | | |
|---|---|---|---|---|---|
| dum03 | 5345 | 0 | 1 | .11 | .318 |
| dum04 | 5345 | 0 | 1 | .13 | .332 |
| dum05 | 5345 | 0 | 1 | .11 | .309 |
| dum06 | 5345 | 0 | 1 | .09 | .291 |
| dum07 | 5345 | 0 | 1 | .06 | .232 |
| Industry | 5345 | .00 | 4983.83 | 1521.9071 | 983.16416 |
| Dis_NEO_B | 5345 | 0 | 7917 | 3345.03 | 2920.405 |
| Dis_NEO_D | 5345 | 0 | 7918 | 1272.09 | 2439.069 |
| Dis_NEO_A | 5345 | 0 | 7920 | 814.71 | 2037.276 |
| NEO | 5345 | 96.86 | 7919.56 | 5431.8245 | 1609.90282 |
| Valid N (listwise) | 5345 | | | | |

**Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .762 | .581 | .578 | 24426.885 |

a. Predictors: (Constant), Dis_NEO_A, Base, STY1.5, dumexterior, pine_lap, dumSTY, Rent, Update, block_brick, alum_vinyl, dim00, Hispanic, STY1.75, dum98, dum01, Acre, STY1.25, dum99, FINBase, Garage, dum03, Industry, Black, dum05, STY1, dum07, Age, dum02, Income, Area, Education, Dis_NEO_B, Dis_NEO_D, dum06

**ANOVA**

| Model | | Sum of Squares | df | Mean Square | F |
|---|---|---|---|---|---|
| 1 | Regression | 4.388E12 | 34 | 1.291E11 | 216.320 |
| | Residual | 3.168E12 | 5310 | 5.967E8 | |
| | Total | 7.557E12 | 5344 | | |

a. Predictors: (Constant), Dis_NEO_A, Base, STY1.5, dumexterior, pine_lap, dumSTY, Rent, Update, block_brick, alum_vinyl, dim00, Hispanic, STY1.75, dum98, dum01, Acre, STY1.25, dum99, FINBase, Garage, dum03, Industry, Black, dum05, STY1, dum07, Age, dum02, Income, Area, Education, Dis_NEO_B, Dis_NEO_D, dum06

b. Dependent Variable: Price

**Coefficients**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 45255.137 | 4825.443 | | 9.378 | .000 |
| | Acre | 48531.874 | 6304.648 | .075 | 7.698 | .000 |
| | Age | -305.497 | 21.834 | -.161 | -13.992 | .000 |
| | Area | 30.381 | 1.281 | .352 | 23.716 | .000 |
| | Base | 13.615 | 1.857 | .083 | 7.333 | .000 |
| | FINBase | 19.150 | 2.678 | .068 | 7.151 | .000 |
| | Garage | 17.666 | 1.812 | .093 | 9.751 | .000 |
| | Update | 12657.339 | 2420.772 | .048 | 5.229 | .000 |
| | Black | -240.778 | 36.049 | -.079 | -6.679 | .000 |
| | Hispanic | -40.023 | 80.678 | -.006 | -.496 | .620 |
| | Rent | -232.876 | 36.760 | -.098 | -6.335 | .000 |
| | Income | .112 | .071 | .024 | 1.567 | .117 |
| | Education | 665.052 | 44.092 | .235 | 15.083 | .000 |
| | STY1 | -6847.707 | 1066.209 | -.085 | -6.422 | .000 |
| | STY1.25 | -2122.386 | 1414.632 | -.016 | -1.500 | .134 |
| | STY1.5 | 895.241 | 1407.488 | .006 | .636 | .525 |
| | STY1.75 | 504.693 | 1164.025 | .004 | .434 | .665 |
| | dumSTY | -2035.365 | 3996.636 | -.005 | -.509 | .611 |
| | alum_vinyl | -2021.958 | 855.839 | -.021 | -2.363 | .018 |
| | block_brick | 1133.498 | 3041.977 | .003 | .373 | .709 |
| | pine_lap | 12185.087 | 12254.827 | .009 | .994 | .320 |
| | dumexterior | -7891.549 | 3571.319 | -.020 | -2.210 | .027 |
| | dum98 | -37565.647 | 3091.265 | -.291 | -12.152 | .000 |
| | dum99 | -32030.141 | 3117.633 | -.256 | -10.274 | .000 |
| | dim00 | -30512.982 | 3094.900 | -.238 | -9.859 | .000 |
| | dum01 | -21274.617 | 3103.843 | -.167 | -6.854 | .000 |
| | dum02 | -16658.057 | 3062.360 | -.142 | -5.440 | .000 |
| | dum03 | -9343.866 | 3062.411 | -.079 | -3.051 | .002 |
| | dum05 | 3298.492 | 1412.522 | .027 | 2.335 | .020 |
| | dum06 | -1367.242 | 3906.718 | -.011 | -.350 | .726 |
| | dum07 | -12052.347 | 4072.869 | -.074 | -2.959 | .003 |

Coefficients (cont'd).

| | | | | | | |
|---|---|---|---|---|---|---|
| | Industry | 2.415 | .413 | .063 | 5.853 | .000 |
| | Dis_NEO_B | 1.810 | .320 | .141 | 5.649 | .000 |
| | Dis_NEO_D | 1.211 | .460 | .079 | 2.633 | .008 |
| | Dis_NEO_A | 1.572 | .556 | .085 | 2.830 | .005 |

a. Dependent Variable: Price

**Excluded Variables**

| Model | | Beta In | t | Sig. | Partial Correlation | Collinearity Statistics |
|---|---|---|---|---|---|---|
| | | | | | | Tolerance |
| | STY2 | .[a] | . | . | . | .000 |
| | wood | .[a] | . | . | . | .000 |
| | dum04 | .[a] | . | . | . | .000 |

a. Predictors in the Model: (Constant), Dis_NEO_A, Base, STY1.5, dumexterior, pine_lap, dumSTY, Rent, Update, block_brick, alum_vinyl, dim00, Hispanic, STY1.75, dum98, dum01, Acre, STY1.25, dum99, FINBase, Garage, dum03, Industry, Black, dum05, STY1, dum07, Age, dum02, Income, Area, Education, Dis_NEO_B, Dis_NEO_D, dum06

b. Dependent Variable: Price

## APPENDIX C Regression Analysis for BUILDERS

**Descriptive Statistics**

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Price | 6543 | 6000 | 389888 | 81515.86 | 34809.996 |
| Acre | 6543 | .028 | .997 | .12415 | .052845 |
| Age | 6543 | 1 | 152 | 81.12 | 19.396 |
| Area | 6543 | 400 | 5082 | 1172.27 | 416.152 |
| Base | 6543 | 0 | 2307 | 688.94 | 224.227 |
| FINBase | 6543 | 0 | 1338 | 53.77 | 149.723 |
| Garage | 6543 | 0 | 1660 | 212.75 | 193.592 |
| Update | 6543 | 0 | 1 | .02 | .141 |
| Black | 6543 | 3.5 | 66.7 | 16.834 | 12.5167 |
| Hispanic | 6543 | 1.0 | 33.8 | 11.620 | 5.3977 |
| Rent | 6543 | 4.57 | 86.82 | 36.6906 | 18.13642 |
| Income | 6543 | 10323 | 60063 | 33260.09 | 8526.255 |
| Education | 6543 | 7.3 | 69.2 | 30.362 | 14.2917 |
| Poverty | 6543 | 1.25 | 53.77 | 19.7057 | 10.26321 |
| STY1 | 6543 | 0 | 1 | .36 | .480 |
| STY1.25 | 6543 | 0 | 1 | .11 | .310 |
| STY1.5 | 6543 | 0 | 1 | .08 | .264 |
| STY1.75 | 6543 | 0 | 1 | .11 | .307 |
| STY2 | 6543 | 0 | 1 | .35 | .476 |
| dumSTY | 6543 | 0 | 1 | .01 | .078 |
| alum_vinyl | 6543 | 0 | 1 | .30 | .456 |
| block_brick | 6543 | 0 | 1 | .02 | .155 |
| pine_lap | 6543 | 0 | 1 | .00 | .049 |
| wood | 6543 | 0 | 1 | .67 | .471 |
| dumexterior | 6543 | 0 | 1 | .01 | .095 |
| dum98 | 6543 | 0 | 1 | .09 | .291 |
| dum99 | 6543 | 0 | 1 | .10 | .300 |
| dim00 | 6543 | 0 | 1 | .10 | .300 |
| dum01 | 6543 | 0 | 1 | .10 | .306 |
| dum02 | 6543 | 0 | 1 | .12 | .320 |

Descriptive Statistics (cont'd)

| | | | | | |
|---|---|---|---|---|---|
| dum03 | 6543 | 0 | 1 | .11 | .317 |
| dum04 | 6543 | 0 | 1 | .12 | .327 |
| dum05 | 6543 | 0 | 1 | .10 | .305 |
| dum06 | 6543 | 0 | 1 | .09 | .292 |
| dum07 | 6543 | 0 | 1 | .05 | .224 |
| Industry | 6543 | .00 | 4279.95 | 1326.1126 | 899.77478 |
| Dis_BUI_B | 6543 | .00 | 7915.88 | 3464.7455 | 3035.15519 |
| Dis_BUI_D | 6543 | 0 | 7915 | 1257.80 | 2481.261 |
| Dis_BUI_A | 6543 | 0 | 7909 | 800.76 | 2064.967 |
| BUI | 6543 | 103.74 | 7915.88 | 5523.3038 | 1830.64822 |
| Valid N (listwise) | 6543 | | | | |

**Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .769 | .592 | .590 | 22299.002 |

a. Predictors: (Constant), Dis_BUI_A, pine_lap, dumSTY, FINBase, dumexterior, STY1.5, Industry, Update, STY1.75, dum98, block_brick, Garage, dum99, dim00, alum_vinyl, STY1.25, dum01, Acre, Black, Base, dum03, Hispanic, dum05, dum07, STY2, Age, dum02, Income, Area, Education, Rent, Dis_BUI_B, Dis_BUI_D, dum06

**ANOVA**

| Model | | Sum of Squares | df | Mean Square | F |
|---|---|---|---|---|---|
| 1 | Regression | 4.691E12 | 34 | 1.380E11 | 277.476 |
| | Residual | 3.236E12 | 6508 | 4.972E8 | |
| | Total | 7.927E12 | 6542 | | |

a. Predictors: (Constant), Dis_BUI_A, pine_lap, dumSTY, FINBase, dumexterior, STY1.5, Industry, Update, STY1.75, dum98, block_brick, Garage, dum99, dim00, alum_vinyl, STY1.25, dum01, Acre, Black, Base, dum03, Hispanic, dum05, dum07, STY2, Age, dum02, Income, Area, Education, Rent, Dis_BUI_B, Dis_BUI_D, dum06

b. Dependent Variable: Price

**Coefficients**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 49410.215 | 3557.094 | | 13.891 | .000 |
| | Acre | 46222.489 | 5710.872 | .070 | 8.094 | .000 |
| | Age | -292.180 | 19.266 | -.163 | -15.165 | .000 |
| | Area | 30.430 | 1.058 | .364 | 28.749 | .000 |
| | Base | 12.790 | 1.552 | .082 | 8.243 | .000 |
| | FINBase | 14.252 | 2.036 | .061 | 7.000 | .000 |
| | Garage | 19.493 | 1.536 | .108 | 12.691 | .000 |
| | Update | 13575.949 | 2011.039 | .055 | 6.751 | .000 |
| | Black | -159.759 | 30.691 | -.057 | -5.205 | .000 |
| | Hispanic | -552.075 | 72.423 | -.086 | -7.623 | .000 |
| | Rent | -225.507 | 31.234 | -.117 | -7.220 | .000 |
| | Income | .103 | .062 | .025 | 1.662 | .097 |
| | Education | 466.565 | 35.771 | .192 | 13.043 | .000 |
| | STY1.25 | 5067.550 | 983.263 | .045 | 5.154 | .000 |
| | STY1.5 | 6468.453 | 1127.945 | .049 | 5.735 | .000 |
| | STY1.75 | 6188.108 | 1050.981 | .055 | 5.888 | .000 |
| | STY2 | 5141.655 | 864.702 | .070 | 5.946 | .000 |
| | dumSTY | -5537.072 | 3718.662 | -.012 | -1.489 | .137 |
| | alum_vinyl | -716.206 | 651.757 | -.009 | -1.099 | .272 |
| | block_brick | 4235.545 | 1869.107 | .019 | 2.266 | .023 |
| | pine_lap | -1502.035 | 5602.526 | -.002 | -.268 | .789 |
| | dumexterior | -5969.166 | 2916.600 | -.016 | -2.047 | .041 |
| | dum98 | -30269.998 | 2397.321 | -.253 | -12.627 | .000 |
| | dum99 | -23951.685 | 2404.249 | -.206 | -9.962 | .000 |
| | dim00 | -22248.254 | 2400.681 | -.192 | -9.267 | .000 |
| | dum01 | -15204.307 | 2393.345 | -.134 | -6.353 | .000 |
| | dum02 | -9041.400 | 2367.894 | -.083 | -3.818 | .000 |
| | dum03 | -2724.464 | 2366.936 | -.025 | -1.151 | .250 |
| | dum05 | 2263.631 | 1177.146 | .020 | 1.923 | .055 |
| | dum06 | 4002.916 | 2957.392 | .034 | 1.354 | .176 |

Coefficients (cont'd).

| | | | | | | |
|---|---|---|---|---|---|---|
| | dum07 | -5819.920 | 3061.496 | -.037 | -1.901 | .057 |
| | Industry | .534 | .373 | .014 | 1.431 | .152 |
| | Dis_BUI_B | .991 | .210 | .086 | 4.717 | .000 |
| | Dis_BUI_D | 1.756 | .334 | .125 | 5.255 | .000 |
| | Dis_BUI_A | .832 | .382 | .049 | 2.175 | .030 |

a. Dependent Variable: Price

**Excluded Variables**

| Model | | Beta In | t | Sig. | Partial Correlation | Collinearity Statistics |
|---|---|---|---|---|---|---|
| | | | | | | Tolerance |
| | STY1 | .[a] | . | . | . | .000 |
| | wood | .[a] | . | . | . | .000 |
| | dum04 | .[a] | . | . | . | .000 |

a. Predictors in the Model: (Constant), Dis_BUI_A, pine_lap, dumSTY, FINBase, dumexterior, STY1.5, Industry, Update, STY1.75, dum98, block_brick, Garage, dum99, dim00, alum_vinyl, STY1.25, dum01, Acre, Black, Base, dum03, Hispanic, dum05, dum07, STY2, Age, dum02, Income, Area, Education, Rent, Dis_BUI_B, Dis_BUI_D, dum06

b. Dependent Variable: Price

# APPENDIX D Regression Analysis for ALL SITES

**Descriptive Statistics**

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Price | 8458 | 6000 | 500282 | 82912.56 | 37848.798 |
| Acre | 8458 | .028 | 1.130 | .13165 | .062010 |
| Age | 8458 | 1 | 152 | 78.10 | 20.204 |
| Area | 8458 | 400 | 5082 | 1147.67 | 412.148 |
| Base | 8458 | 0 | 2307 | 682.34 | 241.177 |
| FINBase | 8458 | 0 | 1457 | 58.77 | 159.847 |
| Garage | 8458 | 0 | 1660 | 223.65 | 196.523 |
| Update | 8458 | 0 | 1 | .02 | .136 |
| Black | 8458 | 3.5 | 66.7 | 17.372 | 12.8498 |
| Hispanic | 8458 | 1.0 | 33.8 | 12.476 | 5.6853 |
| Rent | 8458 | 4.57 | 86.82 | 34.7491 | 17.06897 |
| Income | 8458 | 10323 | 60063 | 33423.02 | 9211.719 |
| Education | 8458 | 7.3 | 69.2 | 29.219 | 14.8873 |
| Poverty | 8458 | 1.25 | 53.77 | 20.1501 | 11.27779 |
| STY1 | 8458 | 0 | 1 | .39 | .488 |
| STY1.25 | 8458 | 0 | 1 | .12 | .319 |
| STY1.5 | 8458 | 0 | 1 | .08 | .264 |
| STY1.75 | 8458 | 0 | 1 | .10 | .294 |
| STY2 | 8458 | 0 | 1 | .31 | .465 |
| dumSTY | 8458 | 0 | 1 | .01 | .083 |
| alum_vinyl | 8458 | 0 | 1 | .30 | .457 |
| block_brick | 8458 | 0 | 1 | .02 | .149 |
| pine_lap | 8458 | 0 | 1 | .00 | .043 |
| wood | 8458 | 0 | 1 | .67 | .471 |
| dumexterior | 8458 | 0 | 1 | .01 | .091 |
| dum98 | 8458 | 0 | 1 | .09 | .287 |
| dum99 | 8458 | 0 | 1 | .10 | .300 |
| dim00 | 8458 | 0 | 1 | .10 | .300 |
| dum01 | 8458 | 0 | 1 | .10 | .306 |
| dum02 | 8458 | 0 | 1 | .11 | .319 |

Descriptive Statistics (cont'd)

| | | | | | |
|---|---|---|---|---|---|
| dum03 | 8458 | 0 | 1 | .11 | .317 |
| dum04 | 8458 | 0 | 1 | .12 | .328 |
| dum05 | 8458 | 0 | 1 | .11 | .307 |
| dum06 | 8458 | 0 | 1 | .09 | .291 |
| dum07 | 8458 | 0 | 1 | .06 | .228 |
| Industry | 8458 | .00 | 4983.83 | 1326.9808 | 918.43984 |
| Dis_BFs_B | 8458 | .00 | 7919.65 | 3189.9175 | 2914.87682 |
| Dis_BFs_D | 8458 | 0 | 7918 | 1161.17 | 2329.618 |
| Dis_BFs_A | 8458 | 0 | 7918 | 751.13 | 1957.574 |
| BFs | 8458 | 96.86 | 7919.65 | 5102.2176 | 1951.80243 |
| Valid N (listwise) | 8458 | | | | |

**Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .789 | .623 | .621 | 23291.119 |

a. Predictors: (Constant), Dis_BFs_A, pine_lap, Base, dumexterior, STY1.5, Black, dumSTY, Update, dum98, STY1.75, Industry, block_brick, dum99, Acre, dim00, STY1.25, dum01, alum_vinyl, FINBase, Garage, dum03, Hispanic, dum05, Age, dum07, STY2, dum02, Income, Area, Education, Rent, Dis_BFs_D, Dis_BFs_B, dum06

**ANOVA**

| Model | | Sum of Squares | df | Mean Square | F |
|---|---|---|---|---|---|
| 1 | Regression | 7.546E12 | 34 | 2.219E11 | 409.107 |
| | Residual | 4.569E12 | 8423 | 5.425E8 | |
| | Total | 1.211E13 | 8457 | | |

a. Predictors: (Constant), Dis_BFs_A, pine_lap, Base, dumexterior, STY1.5, Black, dumSTY, Update, dum98, STY1.75, Industry, block_brick, dum99, Acre, dim00, STY1.25, dum01, alum_vinyl, FINBase, Garage, dum03, Hispanic, dum05, Age, dum07, STY2, dum02, Income, Area, Education, Rent, Dis_BFs_D, Dis_BFs_B, dum06

b. Dependent Variable: Price

**Coefficients**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 31406.776 | 3458.184 | | 9.082 | .000 |
| | Acre | 32006.452 | 4523.405 | .052 | 7.076 | .000 |
| | Age | -328.529 | 16.706 | -.175 | -19.665 | .000 |
| | Area | 32.840 | .973 | .358 | 33.752 | .000 |
| | Base | 14.701 | 1.304 | .094 | 11.271 | .000 |
| | FINBase | 14.948 | 1.733 | .063 | 8.624 | .000 |
| | Garage | 19.354 | 1.403 | .100 | 13.791 | .000 |
| | Update | 13644.708 | 1904.567 | .049 | 7.164 | .000 |
| | Black | -167.270 | 27.512 | -.057 | -6.080 | .000 |
| | Hispanic | -79.393 | 67.092 | -.012 | -1.183 | .237 |
| | Rent | -141.045 | 29.924 | -.064 | -4.713 | .000 |
| | Income | .304 | .050 | .074 | 6.050 | .000 |
| | Education | 582.281 | 30.344 | .229 | 19.190 | .000 |
| | STY1.25 | 3263.780 | 866.950 | .028 | 3.765 | .000 |
| | STY1.5 | 5567.551 | 1035.629 | .039 | 5.376 | .000 |
| | STY1.75 | 6312.080 | 995.026 | .049 | 6.344 | .000 |
| | STY2 | 5184.351 | 808.445 | .064 | 6.413 | .000 |
| | dumSTY | -1852.983 | 3174.548 | -.004 | -.584 | .559 |
| | alum_vinyl | -1621.470 | 593.363 | -.020 | -2.733 | .006 |
| | block_brick | 708.062 | 1766.149 | .003 | .401 | .688 |
| | pine_lap | -3969.895 | 5846.635 | -.005 | -.679 | .497 |
| | dumexterior | -5202.279 | 2797.174 | -.013 | -1.860 | .063 |
| | dum98 | -35507.496 | 1954.686 | -.269 | -18.165 | .000 |
| | dum99 | -30224.136 | 1954.297 | -.239 | -15.465 | .000 |
| | dim00 | -28294.259 | 1953.785 | -.224 | -14.482 | .000 |
| | dum01 | -19343.178 | 1950.914 | -.157 | -9.915 | .000 |
| | dum02 | -13936.576 | 1924.220 | -.117 | -7.243 | .000 |
| | dum03 | -7973.187 | 1923.234 | -.067 | -4.146 | .000 |
| | dum05 | 1619.622 | 1075.297 | .013 | 1.506 | .132 |
| | dum06 | 2164.144 | 2408.989 | .017 | .898 | .369 |
| | dum07 | -7838.495 | 2515.793 | -.047 | -3.116 | .002 |

Coefficients (cont'd).

| | | | | | | |
|---|---|---|---|---|---|---|
| | Industry | 1.261 | .325 | .031 | 3.886 | .000 |
| | Dis_BFs_B | 2.343 | .212 | .180 | 11.063 | .000 |
| | Dis_BFs_D | 2.103 | .306 | .129 | 6.869 | .000 |
| | Dis_BFs_A | 1.242 | .355 | .064 | 3.497 | .000 |

a. Dependent Variable: Price

**Excluded Variables**

| Model | | Beta In | t | Sig. | Partial Correlation | Collinearity Statistics |
|---|---|---|---|---|---|---|
| | | | | | | Tolerance |
| | STY1 | .[a] | . | . | . | .000 |
| | wood | .[a] | . | . | . | .000 |
| | dum04 | .[a] | . | . | . | .000 |

a. Predictors in the Model: (Constant), Dis_BFs_A, pine_lap, Base, dumexterior, STY1.5, Black, dumSTY, Update, dum98, STY1.75, Industry, block_brick, dum99, Acre, dim00, STY1.25, dum01, alum_vinyl, FINBase, Garage, dum03, Hispanic, dum05, Age, dum07, STY2, dum02, Income, Area, Education, Rent, Dis_BFs_D, Dis_BFs_B, dum06

b. Dependent Variable: Price

## APPENDIX E Log-Linear Functional for ALL SITES

**Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .744 | .554 | .552 | .3328298 |

a. Predictors: (Constant), Dis_BFs_A, pine_lap, Base, dumexterior, STY1.5, Black, dumSTY, Update, dum98, STY1.75, block_brick, dim00, Acre, dum99, STY1.25, alum_vinyl, dum01, FINBase, Huspanic, Garage, dum03, STY2, dum05, dum07, Age, dum02, Income, Area, Education, Rent, Dis_BFs_D, Dis_BFs_B, dum06

**ANOVA**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 1159.024 | 33 | 35.122 | 317.055 | .000 |
| | Residual | 933.174 | 8424 | .111 | | |
| | Total | 2092.198 | 8457 | | | |

a. Predictors: (Constant), Dis_BFs_A, pine_lap, Base, dumexterior, STY1.5, Black, dumSTY, Update, dum98, STY1.75, block_brick, dim00, Acre, dum99, STY1.25, alum_vinyl, dum01, FINBase, Huspanic, Garage, dum03, STY2, dum05, dum07, Age, dum02, Income, Area, Education, Rent, Dis_BFs_D, Dis_BFs_B, dum06

b. Dependent Variable: LnPrice

**Coefficients**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 10.780 | .049 | | 218.498 | .000 |
| | Acre | .219 | .065 | .027 | 3.396 | .001 |
| | Age | -.004 | .000 | -.152 | -15.707 | .000 |
| | Area | .000 | .000 | .292 | 25.392 | .000 |
| | Base | .000 | .000 | .108 | 11.967 | .000 |
| | FINBase | .000 | .000 | .046 | 5.802 | .000 |
| | Garage | .000 | .000 | .120 | 15.138 | .000 |
| | Update | .220 | .027 | .060 | 8.091 | .000 |
| | Black | -.004 | .000 | -.093 | -9.165 | .000 |
| | Huspanic | -.002 | .001 | -.023 | -2.071 | .038 |
| | Rent | -.002 | .000 | -.069 | -4.774 | .000 |

Coefficients (cont'd).

| | | | | | | |
|---|---|---|---|---|---|---|
| | Income | 7.261E-7 | .000 | .013 | 1.017 | .309 |
| | Education | .008 | .000 | .227 | 17.878 | .000 |
| | STY1.25 | .067 | .012 | .043 | 5.392 | .000 |
| | STY1.5 | .080 | .015 | .042 | 5.409 | .000 |
| | STY1.75 | .110 | .014 | .065 | 7.753 | .000 |
| | STY2 | .106 | .011 | .099 | 9.303 | .000 |
| | dumSTY | .033 | .045 | .006 | .725 | .468 |
| | alum_vinyl | -.025 | .008 | -.023 | -3.009 | .003 |
| | block_brick | -.036 | .025 | -.011 | -1.440 | .150 |
| | pine_lap | -.020 | .084 | -.002 | -.238 | .812 |
| | dumexterior | -.146 | .040 | -.027 | -3.652 | .000 |
| | dum98 | -.569 | .028 | -.328 | -20.366 | .000 |
| | dum99 | -.503 | .028 | -.303 | -18.017 | .000 |
| | dim00 | -.460 | .028 | -.277 | -16.469 | .000 |
| | dum01 | -.346 | .028 | -.213 | -12.422 | .000 |
| | dum02 | -.266 | .027 | -.170 | -9.658 | .000 |
| | dum03 | -.188 | .027 | -.120 | -6.856 | .000 |
| | dum05 | .031 | .015 | .019 | 1.997 | .046 |
| | dum06 | -.003 | .034 | -.002 | -.101 | .920 |
| | dum07 | -.168 | .036 | -.077 | -4.663 | .000 |
| | Dis_BFs_B | 4.031E-5 | .000 | .236 | 13.358 | .000 |
| | Dis_BFs_D | 2.017E-5 | .000 | .094 | 4.618 | .000 |
| | Dis_BFs_A | 1.856E-5 | .000 | .073 | 3.669 | .000 |

a. Dependent Variable: LnPrice

**Excluded Variables**

| Model | | Beta In | t | Sig. | Partial Correlation | Collinearity Statistics Tolerance |
|---|---|---|---|---|---|---|
| | STY1 | .[a] | . | . | . | .000 |
| | wood | .[a] | . | . | . | .000 |
| | dum04 | .[a] | . | . | . | .000 |

a. Predictors in the Model: (Constant), Dis_BFs_A, pine_lap, Base, dumexterior, STY1.5, Black, dumSTY, Update, dum98, STY1.75, block_brick, dim00, Acre, dum99, STY1.25, alum_vinyl, dum01, FINBase, Huspanic, Garage, dum03, STY2, dum05, dum07, Age, dum02, Income, Area, Education, Rent, Dis_BFs_D, Dis_BFs_B, dum06

b. Dependent Variable: LnPrice

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