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## CAPITALIZATION OF GREEN SPACE AND WATER QUALITY INTO RESIDENTIAL HOUSING VALUES

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Willie B. Bedell, Student

Dr. Steven Buck, Major Professor

Dr. Carl R. Dillon, Director of Graduate Studies

CAPITALIZATION OF GREEN SPACE AND WATER QUALITY INTO  
RESIDENTIAL HOUSING VALUES

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THESIS

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A thesis submitted in partial fulfillment of the  
requirements for the degree of Master of Science in the  
College of Agriculture, Food and Environment  
at the University of Kentucky

By

Willie B. Bedell

Lexington, Kentucky

Director: Steven Buck, Assistant Professor of Agricultural Economics

Lexington, Kentucky

2017

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## ABSTRACT OF THESIS

### CAPITALIZATION OF GREEN SPACE AND WATER QUALITY INTO RESIDENTIAL HOUSING VALUES

This thesis investigates how proximity to parks, historic district designations, and water quality are valued at residential housing prices. The first essay argues that the negative influences of parks and historic districts, if not noticed, could promote negative externalities and unincentivized investments. I find a negative impact on housing values for a close proximity to a park, suggesting disamenities in park features. When the boundary discontinuity and park amenities are considered, I find a positive valuation for a park. Overall, these results imply a mixed influence of parks on homeowners. From the historic district standpoint, I find a positive valuation of the local historic districts over the surrounding neighborhoods. The latter findings indicate that the benefits of locally designated areas outweigh the negative impacts. The second essay researches a probable lead risk in the water supply on the residential market. I argue strongly for the possibility of hidden-type information relative to lead in water supplies. I find that the influence of lead risk in their water supply is not statistically significant. The test for asymmetric information validates the expectation that homes in the relatively high lead-risk neighborhoods might not be informed of the level of lead-risk in their water supply.

**KEYWORDS:** Parks, Historic Districts, Hedonic Price, Water Quality, Lead Risk,  
Information Asymmetries

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November 27, 2017

CAPITALIZATION OF GREEN SPACE AND WATER QUALITY INTO  
RESIDENTIAL HOUSING VALUES

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## DEDICATION

I dedicate this thesis to my mother, Marie Johnson and siblings, Rammie, Jocee, Devine, and Johnson, for their family love and affection.

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## **CHAPTER ONE: INTRODUCTION**

It is easy to recognize environmental issues when the media relay news on climate change, smog cities, polluted water supplies, and cancer-inducing elements in our communities. The first essay, presented in Chapter 2, investigates how parks and historic districts influence the values of residential homes. Chapter 3 examines the impact a probable lead contamination level in the water supply has on residential properties. Empirically, I used hedonic valuation throughout this thesis to obtain parks, historic districts, and water lead risks' implicit values.

The green space campaign aims to protect the environment, thus supporting other forms of life and caring for the environment. Parks are financed and expected to support health and to conserve green spaces for future generations. However, parks can face challenges or cause negative externalities, Walls (2009) and APA (2017). The environment is also maintained through historic districts. Historic districts are likely to boost environmental conservation, sustainability, reduce pollution, and support energy-efficient policies, Rocchi (2015). Nevertheless, designated areas could face challenges of radical change. Historic districts could adversely affect conservation goals and property investments. These designated areas could also displace low-income residents, Clark and Herrin (1997) and Fein (1985). In addition to investigating green space, this thesis evaluates the issue of lead poisoning risk. Lead poisoning in the United States has been an environmental and health case since the mid-1950s. Contemporarily, lead contaminations in water supplies became a trending issue because of the Flint, Michigan water crisis in 2014. Some of the main challenges of lead contamination remained identifying sources of lead materials and financing water infrastructures to mitigate lead risks in water supplies.

To measure the values or influences of these environmental issues on homeowners, for which there exist no established markets, I subscribe to the hedonic model. Important to the environmental and natural resource discipline, the hedonic analysis is employed to measure environmental goods. Hedonic analysis connects environmental goods, services, or concerns as linked attributes to a market. By this association, an implicit value is revealed. For example, the hedonic approach has been used to estimate how people value environmental issues like air pollution, noise level, and water quality via the residential property market. The hedonic model, which links Chapter 2 and 3 in this thesis, combines structural, neighborhood, and environmental variables to measure parks and historic districts' implicit values, as well as lead risk levels in the water supply. Not only is the hedonic model a consolidating force for my essays, but also the dataset covering the residential market of Fayette County, Kentucky. The Property Valuation Administrator of Fayette County, Kentucky made available the dataset of over 90,000 observations. This dataset, from which I measured the influences of parks, historic districts, and water quality levels, date from 2000 to 2016. I merged the PVA data to other secondary information and my environmental variables of interest from Fayette County, Kentucky to support the application of the hedonic model.

Chapter 2 concentrates on examining parks and historic districts hedonic values. I employed an ordinary least squares regression to evaluate the influences of parks and historic districts on residential homes. I also applied a boundary discontinuity procedure to estimates parks and historic districts' values via properties that lie in the same geographical neighborhoods. The ordinary least squares technique finds a negative implicit value for parks. This result indicates that parks host amenities which might negatively affect their

use-value. The boundary discontinuity results find a positive value for parks, indicating a positive use-value. Applying the hedonic model to analyze designated areas, I also find that local historic districts have a positive influence on the residential market. This implies that local historic districts have benefits and exert a greater influence on the surrounding neighborhoods.

In Chapter 3, I discussed the problem of identifying lead risk in the residential water supply. My argument is segmented into two phases. The first phase assessed the probable water lead risks impact on residential homes' values. The second phase tested the argument that homeowners in the high lead risk water zones may have little information on their water supply, compared to the low lead risk neighborhoods. Results from the ordinary least squares and instrumental variable approaches show no statistical difference to avoid water lead risks. Results from the propensity score matching find that people will pay a higher price to live in a low-risk water neighborhood. The latter result might be susceptible to omitted variable bias. These results further reflect that homeowners care more about the home's structural characteristics and neighborhoods' income levels than lead risks. Results from the second phase show that the average growth rate for homes in the high lead risk areas is greater than the low-risk neighborhoods. The average growth rate is the appreciated price from the resales of residential homes. This growth rate results imply that home buyers in the high-risk areas might be less informed about lead risk.

My essays contribute to the literature by investigating the combined implicit effects of park amenities and historical districts, assessing the hedonic value of a probable lead exposure risk in drinking water, and testing for the possibility of lead risk asymmetric information in the residential market. I identified potential gaps and provided

recommendations to support current policies addressing these environmental issues. I recommend that parks' authorities use surveys to detect and mitigate the negative parks externalities. Besides, I call on historic district authorities to adopt communications and actions which could combat gentrification and support societal, environmental, and economic integration. In the vein of lead risk, I suggest that water and related authorities should ensure that water-lead problems are fully disclosed during the sales of residential homes, in conjunction with the lead paint full-disclosure regulations.

**CHAPTER TWO: HEDONIC VALUATION OF GREEN SPACE IN FAYETTE  
COUNTY, KENTUCKY: INVESTIGATING PARKS AND HISTORICAL  
DISTRICTS**

Parks are green spaces which might promote health, recreational benefits, and private investments. A historic designation can indicate high-quality craftsmanship with durable materials and an attractive aesthetic. I investigate the influences of parks and historic district designations on homeowners. Using data provided by the Property Valuation Administrator of Fayette County, Kentucky, I employ a hedonic analysis to investigate the implicit values of parks and historic districts. I find mixed valuations for parks and report a positive influence associated with historic districts.



## I. Introduction

Parks play a key role in the drive for green space and the accompanying environmental attributes. Parks, which are financed to bring recreation benefits and social life to communities, are valued for their amenities. To depict a financing picture for parks, Lexington government in Fayette County, Kentucky assigned \$1,542,000 in funds and \$2,955,000 in Bonds for the 2016/2017 Fiscal Year to the Parks and Recreation for maintenance and development projects. In view of designated areas, homeowners residing in historic districts may enjoy environmentally friendly homes, tax incentives, and investment benefits. To provide an investment picture for historic districts, homeowners residing in historic districts in the State of Kentucky had invested, on average, \$123,537 in historic properties by 2015. These investments, to some extent, are tied to Federal, State, and local tax benefits, such as preservation tax deductions. Specifically, I ask the research question: How does proximity to a park and historical district designation affect residential housing values? I expect that parks and historic district designations would positively influence the values of residential homes.

This study contributes to the green space or environmental valuation literature by investigating two environmental attributes that exist in the same spatial scope. Studies have independently measured the value of parks and historic districts using willingness to pay analyses. Livy and Klaiber (2010) examined the values of amenities in parks, as parks change over time. Although their results showed mixed valuation for parks, the authors argued that nearness to a park is not highly valued and ignoring heterogeneity in park amenities is not advisable. Klaiber and Phaneuf (2010), using a utility sorting model, show that the housing market, a component of location, structure, and time, is necessary to

analyze open space. Livy and Klaiber (2010) find that utility maximization of open space depends on the location and the open space type. In the realm of historic district literature, Clark and Herrin (1997) emphasized that historic preservation strategy is employed by cities' authorities to revive declining metropolitan areas and support renewed interest in designated areas. Clark and Herrin evidently show that historic district put forth a net positive effect on the residential property. Coulson and Lahr's (2005) findings showed a higher value for properties in historical designations: Local designations have a positive and significant effect, while national historic districts have a non-significant effect on residential properties. Regardless of studies showing the positive effects of historically designated areas, scholarships like Heudorfer (1975) and Gale (1991) find a neutral or negative influence of historic district on properties. Fein (1985) sees historic districts as a commitment to preserve city neighborhoods for the privileged, claiming a gentrification phenomenon.

My study is theoretically underpinned by the hedonic framework. The hedonic model is built on the pioneering theories and assumptions of Lancaster (1966) and Rosen (1974). Lancaster argues that consumption activities produce a vector of characteristics and individuals will optimally choose the solution that maximizes their utilities for the characteristics. Rosen (1974) supports the hedonic theory by explaining that differentiated products consist of a vector of objective measurable characteristics. Hedonic prices show implicit prices of assigned characteristics, as reveal to consumers by sellers. Aligning the hedonic theory to this study, the value of residential homes depends not only on the structural characteristics but also on the neighborhood and environmental attributes. As a result, hedonic prices will implicitly show the values for parks and historic districts. The

dataset used in this study incorporates information on home sales transactions, house characteristics, and neighborhood and environmental attributes. My dataset for this essay consists of 64,727 observations. The dataset was built on the residential housing market in Fayette County, Kentucky and it covered a 17-year period, 2000 to 2016. Fayette County, Kentucky's Property Valuation Administrator (PVA) is the main source of my data. Accumulating information from different data sources, I mapped and merged all data using the Quantum Geo-information system (QGIS) software. Hence, I regress the log of the sale price on the structural, neighborhood, and environmental attributes to accurately evaluate the impact of parks and historic districts on the residential market. Herein, I used a covariate approach for my identification strategy. The inclusion of covariates (time fixed effects, housing & neighborhood attributes, as well as school and park fixed effects) are presented in a stepwise approach. Results from the hedonic models steered the stage for the implications and discussions.

The organization of this paper is structured as follows: Section 2 presents the background of the study; Section 3 reviews park and historic district studies; Section 4 and 5 respectively describe the theoretical model and the data; Section 6 hosts the designs of my econometric model, and Section 7 reveals the empirical findings. The study is finalized in Section 8 and 9, where I discussed my findings and provide a conclusion.

## **II. Background**

Fayette County, Kentucky provides a green space and urban-rural context that this study exploits to evaluate Fayette County, Kentucky provides a green space and urban-rural context that this study exploits to evaluate the use-value of environmental attributes,

namely park features, and historically designated areas. In Fayette County, Kentucky, green space is contextualized as a heritage to environmental amenities, including interwoven qualities of urban-rural landscapes, farmsteads, lands, parks, trees, and water networks. Green space in Fayette County, Kentucky has positive externalities that directly benefits tourism, businesses, and the public. Supported by Kentucky's State statutes, there are Comprehensive plans that serve as guidelines to maintain green space and to enhance economic growth and land use management in Fayette County, Kentucky. Fayette County, Kentucky's 2007 and 2013 Comprehensive plans project environmental and neighborhood goals that are built on the frameworks of protecting, promoting, and designing open space and green infrastructure, and monitoring and strategizing to reduce pollutions of air water, light, and noise. These Plans guide both sellers and buyers of residential, commercial, and industrial properties in Fayette County, Kentucky to acknowledge land preservation and to promote green infrastructures. Specifically, environmental goals in these plans drive sustainability in parks and designated districts. Fayette County, Kentucky consists of more than 100 parks and 17 historic districts. Parks in Fayette County, Kentucky are highly variable in types, sizes, recreational facilities, and provide support to communities' livelihood activities. Local historical districts are dispersed throughout Fayette County, Kentucky. These historic neighborhoods also exhibit variability. Illustratively, historically designated areas in Fayette County, Kentucky can be found close to the central business district or within suburban neighborhoods.

Parks and historic districts play a key role in green space campaigns. Ideally, parks are appreciated for the usefulness of their amenities. Nationwide, park types, for instance, community, neighborhood, and golf-course parks have associated positive externalities,

NRPA (2017). Community parks represent health and a diversified community space. Neighborhood parks contribute to recreation and physical activities. Golf-course parks are noted for their relaxing environment, green fields, rolling hills, streams and recreational activities; State-owned parks offer positive activities ranging from hiking and picnicking to wildlife habitat management and recreational use. In the same spirit of exhibiting positive externalities, there are benefits of establishing and living in local historic areas. Designated districts support environmentally friendly homes, counting energy efficient residents, enjoying socio-psychological benefits, and protecting residential investments, Rocchi (2015) and O'Donnell (1998). Historic districts encourage communities to retain and use their existing resources in an effort to contribute to the reduction of pollution, congestion, and landfill waste. In the intentions of improving the environment, historic districts may allow communities to incorporate and exercise environmental stewardship and contribute to emergency management decisions, FEMA (2017). Homeowners within historic districts may qualify for tax incentives, as derived from the total value of expenses incurred when preserving the property.

Despite the positive externalities associated with parks and historic districts, there exist problems that could counteract or negatively alter the importance of these green space amenities. Regarding parks, a community park might breed societal challenges such as gangs, drugs, gun violence and noise, APA (2017). Under-utilization and underperformances have raised critical concerns for neighborhood parks, Alliances (2017). Despite the benefits from golf course parks, there might be right of entry, admission fees, and an accompanying property tax. State-owned parks are afflicted with taxes, neglected maintenance, and increased wildfires, State Owned Reservations (2017). Regarding

historic districts, the nightmare of either gentrification or neglect investment is a problem which could hinder investments and positive influences in designated districts. Through gentrification, historic districts may only host residents of middle and upper-middle-class families, Clark and Herrin (1997) and Fein (1985). There are also potential consequences of high maintenance costs and building code regulations that may cause a prisoner's dilemma-like interaction, wherein historic property owners are not motivated to invest in their property maintenance, Coulson and Lahr (2005).

In spite of challenges that could be encountered or widened by parks and historic districts, I concentrate on the question: How does proximity to a park and historical district designation affect residential housing values? I hypothesize that parks and historic districts have positive influences on residential homeowners, because the locals who utilize parks' amenities and live in historic districts might enjoy environmental benefits, as well as public and private investments. My objective of this green space research is to empirically assess the influences of parks and historic districts on residential properties' values. I used the residential market to establish the measure of influence and determine the implicit use-values for parks and historic districts. Use-value reflects utilities and externalities associated with environmental goods or issues.

The massive support toward parks, including projects for development and infrastructure maintenance, is one of the forces backing the study's motivation. Funds for parks are disbursed on playgrounds, outdoor fitness facilities, buildings, and beautification of gardens. In the context of Fayette County, Kentucky, financing parks bring recreational and event benefits, such as afterschool activities, arts and sports, camps, rental facilities, and tourism to residents, Park and Recreation (2017). During 2016/2017 Fiscal Year,

Fayette County, Kentucky government allocated \$1,542,000 in funds to the county's Parks and Recreation for maintenance and replacement of outdated parks equipment. Also, the 2017 Fiscal Year designates \$2,955,000 in Bond for major repairs and improvements of parks. These funds support projects such as the construction of amphitheaters and aquatic centers in existing parks, the designs of proposed parks, and the renovation of playgrounds.

My expectation for historic district valuation is motivated by an investment factor. There are approximately 85,014 historic places listed, with over 13,594 historic districts in the United States. The 2016 Fiscal Year Annual Report of the Federal Tax Incentives for Rehabilitating Historical Districts reported an aggregate investment of 1,039 certified completed projects valued at \$5.85 billion. 57% of these completed projects invested in private housing. For example, by 2015, 832 historic rehabilitation projects were reviewed in Kentucky through the Historic Preservation Tax Credit program. In monetary value, private investments contributed \$647,260,922 to historic rehabilitation. On average, residential homeowners in the State of Kentucky had invested \$123,537 in historic properties. Kentucky Heritage Council consolidates with the Governor and the Preservation Officer to administer Kentucky Preservation Historic Tax Credit program.

### **III. Literature Review**

Hedonic analysis has been instrumental to the discipline of environmental economics, assisting the discipline to value environmental goods. Ridker and Henning (1967) first used the hedonic approach to calculate the significance of air pollution sulfation and its actionable effects on changing property values. Thereafter, environmental studies have applied the hedonic analysis to research noise level, Bjorner *et al.* (1992), woodland cover,

Garrod and Willis (1992), and water quality, Leggett and Bockstael (2000), Rubinfeld (1978), and Brookshire *et al.* (1981). I contribute to the hedonic literature by investigating the combined implicit effects of park amenities and historical districts on property values.

### **A. Parks Hedonic Review**

Livy and Klaiber (2010) scrutinized park amenity values, as parks change over time. The authors re-echoed the unexpected findings that are sometimes associated with park amenities: Residential homeowners will offer a discount to live near a park. Livy and Klaiber warned that if a research is not robust, the research might not carefully observe the bundling hypothesis of parks. Livy and Klaiber argued that, when evaluating park as an environmental good, the aggregate result of proximity to a park is a bundle of positive and negative attributes. Livy and Klaiber (2010) contribute to the literature by way of their investigation which focused on the non-significant statistical results associated with studies on parks, the effects of heterogeneity in park amenities, and the consistency of depreciated values of park amenities over time. I agree with Livy and Klaiber on the notion that each park and its fulfilling amenities require different upkeep attention and that each park is viewed and valued distinctly through the public eyes. Like many traditional hedonic studies, their general model features the first stage hedonic price of a semi-log functional form. Livy and Klaiber (2010) assumptions hold that the hedonic model envelopes a vector of structural characteristics, neighborhood attributes, local park amenities, and time. Using data from the Maryland Property View and Baltimore County Park Renovation between 2000 and 2007, Livy and Klaiber applied fixed effects parsimonious models. Their specific model controlled for housing characteristics, neighborhood attributes, parks' facilities renovated or maintained at a fixed location, and the depreciation effect through time.



Results from the Census Tract, Block group, and property fixed effect models, as constructed by Livy and Klaiber (2010), show that nearness to a park is not highly valued and ignoring heterogeneity in park amenities is not advisable. Their findings report that playground and field renovation have positive and significant estimates, while courts and lighting renovation have negative positive and significant estimates. Park trails did not yield a statistically significant result. Livy and Klaiber attributed the negative significant coefficients to noise, light pollution, increased usage of amenities, and increased night-time activities. Contrariwise, Livy and Klaiber credited the positive and significant coefficients to safer infrastructures, increased desirability by families, and park's green space.

Valuing park allows one to quickly realize the non-market nature of environmental goods, including green and open spaces. The solution to this probing technique is structured in an existing nearby market. The residential market, depicting models of household location choice, is foundational for measuring the willingness to pay for environmental goods, Kuminoff and Pope (2010). Klaiber and Phaneuf (2010) use a utility sorting model to show that the housing market, a component of location, structure, and time, is necessary to analyze open space. A focusing element for consistently and accurately identifying the willingness to pay for park amenities is to control for heterogeneity. Although their study is skewed to policy interventions and open space conversation, Klaiber and Smith (2013) contribute to the literature by emphasizing on the identification of heterogeneity in amenities. Accounting for amenities' heterogeneities might explain the locational decision trade-offs that households make to experience optimal utilization. Klaiber and Phaneuf (2010) conceptual sorting model is built on the basic random utility model. That is, each

household decides to maximize its utility by the house type, spatial location, time, and other neighborhood and observable attributes. Households classify and choose among their local jurisdictions to get the desired public good. They employed a two-stage empirical strategy to recover household heterogeneity and price coefficient. In the context of the Twin Cities of Minnesota (i.e., the Seven-County area) the data presents a case of variability in the types of open space. With the aggregate information constructed on the subsets of a household choice set, residential transaction, land use, and Census data from 1990 and 2000, the data included property values and characteristics, landscape amenities, and the socioeconomic characteristics of households. The authors matched and mapped spatially explicit landscape data to a real estate transaction. Their conclusive results, in part, prioritize the analysis of heterogeneity for open space type and preferences. Their findings show that utility maximization of open space decisively depends on location and type.

The hedonic model and willingness to pay estimators are seriously plagued with endogeneity issues. The hedonic functional forms might either accurately or inaccurately estimate the willingness to pay for environmental attributes. With the intention of choosing the right functional model for environmental inference, Kuminoff *et al.* (2010) questioned which hedonic functional forms are appropriate to evaluate the economic effect of policies which target local public goods, environmental services, and urban amenities. Motivated by Cropper *et al.* (1988), Kuminoff *et al.* (2010) investigated misspecification caused by omitted variable bias in the hedonic model. The challenge of omitted variable bias exists when factors that are important to explain the price, neighborhood characteristics, and environmental variables, such as park features, and designated characteristics, are not observed in the function. This endogeneity issue might lead to an inaccurate estimate of

economic values. Kuminoff *et al.* (2010) constructed a Monte Carlo experiment to probe the accuracy of hedonic functional forms in the quest to mitigate the problem of omitted variable bias. Their Monte Carlo analysis included six functional forms, namely linear, semi-log, double-log, quadratic, linear Box-Cox, and quadratic Box-Cox. The characteristic vectors, as used by Kuminoff *et al.* (2010), encompassed the structural housing attributes, idiosyncratic income, locational preferences, and proximity to open space. They calibrated the model to a data of 104,000 single family housing sales in Wake County, North Carolina between 1992 and 2000. Their findings advised studies to incorporate spatial fixed effects to mitigate the danger of omitted variable bias. Unlike previous findings, their results show that with the spatial fixed effect control, a flexible specification like the quadratic Box-Cox outperforms the parsimonious linear, semi-linear, and double log functional forms. Kuminoff *et al.* (2010)'s work is distinct to the hedonic literature by virtue of its advice that studies should carefully think about the hedonic specifications, account for endogeneity, and encourage the usage of fixed spatial effect, time dummy, and quasi-experiment models.

## **B. Historic District in the Hedonic Literature**

The body of literature covering historic district influence on property valuation has found mixed evidence of positive and negative effects. Clark and Herrin (1997) argued that historic preservation is a tactful strategy employed by cities' authorities to revive declining metropolitan areas and support renewed interest in a designated area. Hence, historic districts host residents of middle and upper-middle-class families (gentrification) and preserve a municipality's tax benefits by encouraging renovation of the residential and commercial properties. The authors use the hedonic price theory on a sample of residential

properties in Sacramento, California to investigate whether positive externalities from a historic preservation designation outweigh the potential negative impacts of a cumbersome set of rules imposed by authorities. Living in a historically preserved district in the United States comes with straight regulations of making an alteration to properties to promote health, safety, and welfare. Clark and Herrin also warned that preservation plans and regulations, which require homeowners to improve deteriorating properties, may not be sufficient to incentivize the property upkeep. As a result, the property value will decrease due to strict rules. The higher cost of renovation could also overwhelm the positive upkeep campaign in historic districts. Fitting the data to 20 historic districts, Clark and Herrin (1997) used a single stage hedonic price model, which viewed housing as a differentiated bundle of structural and neighborhood characteristics. Clark & Herrin assumed information symmetries, zero transaction cost, and a continuous offering of attributes. Their model specified the structural, neighborhood, year, and historic preservation influences on home price through a semi-log functional form to avoid misspecification biases. Clark and Herrin included a control through the interactions of the historic district dummy with the age of the house, and neighborhoods that are in a close proximity to the historic district. The latter covariate may explain the spillover effect of a historic district on nearby properties. Applying the white test correction technique, Clark and Herrin's findings show that historic district put forth a net positive effect on the residential property; a historic district increases the average home sale price by 25 percent. Notwithstanding, they also conclude that the success of the historic district is strongly predicted by the characteristics of the neighborhood.

Leichenko *et al.* (2000) also agreed that designated areas are used as instruments to rejuvenate or to halt neighborhoods deterioration. Leichenko *et al.* questioned the mixed results of the effect of designated areas on property values: Evidence of positive or detracting values. The positive effects of historic districts contain insurance for a better neighborhood quality and a positive spillover effect for neighboring areas. The value detracting aspects include a restriction on alteration and demolition, as well as expensive maintenance. These authors contribute to the literature by examining the effects of historic districts on property values across a larger set of cities, a limitation of previous studies. Their appraisal data contained information from nine cities (Abilene, Dallas, Fort Worth, Grapevine, Laredo, Lubbock, San Antonio, Nacogdoches, and San Marcos), hosting over 6,000 historic properties. Leichenko *et al.* designed selection criteria for comparable and different types of historic districts. Their modeling approach estimated house price as a function of property characteristics, neighborhood location, and historic status. Like Clark and Herrin (1997), Leichenko *et al.* (2000) used a semi-log hedonic specification form of the natural log of price and included a control of the interaction of the historic district with year built to avoid upward bias. Mainly, their results suggested that historic district generally has a positive impact on property values, and historic area is associated with average property value increases ranging between five (5) and twenty percent (20) of the total property value. Their results also indicated that historic district, whether national, state or local, tend to have a mixed effect on housing values.

The formation and support of designated districts is a prevalent tool to preserve cultural heritage through external stimuli such as the 20% national tax credit program. Coulson and Lahr (2005), influence this paper via their emphasis on the potential

ramifications of historic districts. Coulson and Lahr stressed on the negative effects that might deter the interest, influence, and investment in a historic district. Constraints of living in a designated district include the types of refurbishment and rehabilitation that can be undertaken, upkeep maintenance, and building code regulations. The authors framed the constraint scenario into a prisoner's dilemma-like interaction, wherein property owners aren't incentivized to invest in their property maintenance. Over time, neighbors may copy the low-level investment strategy, thus causing a downward spiral of quality on housing stock in the district. As a result, the neighborhood is made worse-off through low investment. Covering the period 1998 to 2002 and sourced through Memphis Landmarks Commissions, Coulson and Lahr's (2005) data included 5,889 observations from historic districts and historic conservation zones. Results from a series of models show that historical designations add 12.6 percent to the property appreciation process. Further evidence shows that local designations have a positive and significant effect, while results belonging to national historic districts were not statistically significant. Another interesting finding by Coulson and Lahr, segmenting historic district into old and new properties, show that new properties benefit more than older properties in a historic district.

Other studies covering designated areas have solely debated that historic districts, though with plans to mitigate neighborhood negative externalities, are believed to depress property values. In this light, difference-in-difference studies report neutral or negative effects on property values by designated districts, Heudorfer (1975), New York Landmarks Conservancy (1977), Samuels (1981), and Gale (1991). Fein (1985) perceived historic district as a commitment to preserve city neighborhoods for the privileged. The socio-judiciary notes, published in the New York University Law Review, stressed that historic

district has the tendency to displace or exclude low-income and minority residents from urban neighborhoods; a gentrification phenomenon.

#### **IV. The Conceptual Hedonic Model**

The theoretical framework in this essay is underpinned by the hedonic model. The hedonic model is built on the pioneering theories and assumptions of Lancaster (1966) and Rosen (1974). A central assumption instantiated by these theorists is the characteristics rationale. Lancaster (1966) consumer theory reflects that goods are goods in a substitution determinate world and inputs' output is a collection of characteristics. Lancaster argued that goods hold characteristics and characteristics give rise to utility; goods have more characteristics, and combined goods possess varying utilities than separate goods. In addition to these arguments, Lancaster (1966) modeled consumer behavior on three basic assumptions. First, Lancaster assumes individual good or a collection of goods is a consumption activity which is associated with the level of activity. It is also assumed that the level of activities associated with a consumer good is linear, objective, and carry intrinsic properties in relation to technology. The second assumption present that consumption activities produce a vector of characteristics in a linear relationship. And lastly, individual possess an ordinal utility function on characteristics and will optimally choose the solution that maximizes his utility for the characteristics.

$$F_k(z, x) = 0, k = 1 \dots m \quad (1)$$

The model in Equation 1 maintains a no one-to-one relationship between the activity vector, indexed by  $k$ , and the collections of characteristics  $z$  and  $x$  that available to the consumers.

Rosen (1974) strongly supports the hedonic theory through his explanation that differentiated products consist of a vector of objective measurable characteristics. In his argument, an observed product price and the tied characteristics signify the hedonic price. One of the main assumptions of Rosen's implicit prices is market equilibrium. In the consumer domain, the price that consumers will be willing to pay for a good, the consumption decision, indicates utility maximization subject to a nonlinear budget constraint. Choosing a basket of goods to maximize satisfaction, consumers will purchase a product that has a unique combination of characteristics to achieve optimal utility.

$$P(z) = U(x, z_1, \dots, z_n; \alpha, y) \quad (2)$$

Equation 2 sums the consumption decision into the consumer bid function, where  $z$  is the product characteristics,  $x$  is all other goods consumed,  $y$  is constraint income, and  $\alpha$  is the taste parameter that varies with each consumer. Regarding the production decision, each producer, acting independently, consider the number of units to produce and the package of specific characteristics to assemble in a locational space.

$$P(z) = C(M, z_1, \dots, z_n; \beta) \quad (3)$$

As projected in Equation 3, producers want to maximize profit by choosing the optimal cost of the number of units to produce  $M$  and the specific characteristics to include,  $z$ . These are based on the factor prices and other production parameters,  $\beta$ . So, the market equilibrium combines buyers and seller's goals through a hedonic price function. Goods have stated prices, valued by sellers, and goods are associated with a fixed characteristic vector, valued by consumers. Thus, setting the stage for the implicit price function, the hedonic function.



$$P(z) = p(z_1, \dots, z_n) \quad (4)$$

Analyzing the theories of Lancaster (1966) and Rosen (1974) in the application of this study, the residential market in Fayette County, Kentucky is a bundle of defined characteristics. Fayette County, Kentucky's housing market reflects characteristics that are orderly valued indirectly in different relative proportions. Recall, the residential market serves as a medium to measure the implicit use-value of environmental goods. Homes package characteristics like structural, neighborhood, environmental, and time attributes. Because households' attractions in Fayette County, Kentucky are influenced by these characteristics, benefits from parks and historic districts in the county might be captured by each household.

$$U_i = (P, H, N, E, T, \varepsilon) \quad (5)$$

In Equation 5, utilities enjoyed by household  $i$  in Fayette County, Kentucky encompass the market clearing price of the home  $P$ , housing characteristics  $H$ , neighborhood and environmental attributes  $N$  and  $E$ , macro-fiscal time reflected in  $T$ , and unobservables  $\varepsilon$ . Note that, the utility function accounts for heterogeneity in the preferential valuation of homes, such as choosing a to live in a historic district or close to a park. The varying characteristics of parks, such as hosting a trail or community center, and if a historic district is in a central business district or on the rural side of Fayette County, Kentucky, might contain different utilities, thus giving rise to different preferences.

In the market equilibrium situation, homeowners in the Fayette County, Kentucky have a bid function that manifests their willingness to accept the household expenditures and to pay for a given utility at a relative budget. Separately, home sellers in Fayette

County, Kentucky are sensitive to their locational decision and the package of characteristics assembled. Revealed by the household market clearing price, the hedonic price function implicitly displays the value of characteristics.

$$P = f(H_1, \dots, H_m; T_1, \dots, T_n, N_1, \dots, N_m; E_1, \dots, E_p, \varepsilon) \quad (6)$$

The expression of attributes like  $H_1, \dots, H_m$  and  $E_1, \dots, E_p$  accounts for the number of characteristics associated with each attribute vector. This also allows for heterogeneous preferences, Klaiber and Phaneuf (2010).

Summed up, the hedonic theory explains that a commodity is a wrapped bundle of characteristics. The value of residential homes depends not only on the structural characteristics of the home but also on the neighborhood and environmental attributes. The hedonic price function is traditionally linear, or it may be nonlinear, so that implicit prices can vary with the level of characteristics, Hanley *et al.* (2007). The hedonic theory assumes information symmetries, low transaction cost, unlimited attributes, and an unsegmented market. These assumptions are potential empirical concerns for the hedonic model. Even accounting for these assumptions, the hedonic model is susceptible to empirical pitfalls, including omitted variable bias, multicollinearity, choice of functional form, market segmentation, expected versus actual characteristics, and altitude to risks. Omitted variable bias causes inaccurate estimates. The choice of functional form influences the value of the implicit prices. Multicollinearity presents the disadvantage of entangled implicit prices, Hanley *et al.* (2007). Consequently, the appropriate hedonic models must consider these empirical caveats and control for these econometric challenges.

## V. Data

Based on the hedonic model designed by this paper, the analysis requires data on home sale transactions, house characteristics, neighborhood and environmental attributes, the economic times, and financial strength of homes in Fayette Kentucky. My dataset consists of 64,727 observations which derive from the residential housing market in Fayette, Kentucky. The dataset covers a 17-year period, 2000 to 2016 and accumulates information from different sources, including Fayette County, Kentucky's Lexington-Urban government, and the US Census Bureau. I mapped and merged the data from all sources using Quantum Geo-Information System (QGIS) techniques. The data-merging Geospatially corresponds to Kentucky Coordinate Reference System: EPSG 102679, NAD 1983 State Plane.

### A. Housing Characteristics and Time Data

Housing characteristics represent the category of structural variables. As shown in Figure 2.1, a dominant portion of Fayette County, Kentucky's residential home transactions, over the 17-year period (2000 to 2016), occurred in the Central South-west region of the county. This residential transaction data is accredited to and provided by the Fayette County, Kentucky's Property Valuation Administrator (PVA). The PVA, an agent of the Kentucky government, collects property data by its Ad valorem authority and taxation role. Through these duties, the PVA stores information on all personal properties, including residential homes. In addition to its data collection responsibilities, the PVA tracks ownership changes and updates building characteristics. Although over 90,000 observed transactions were provided in this study, the precise GIS merging and data cleaning processes finalize the

observations to 64,727 transactions. For instance, I dropped all residential sales below \$16,000 real price to avoid outliers, unrealistic observations, and potential data errors. 16,000 was chosen because more than 100 hedonic studies used \$16,000 as the minimum value for housing price, Kuminoff *et al.* (2010). The residential data in this study capture housing characteristics and time factors, including revealed sale transactions, house age in linear form, square feet of the building, fixed and half bathrooms, number of floors, garage type, and property acreage. Time data are represented by the sale's month and year. See Table 2.1.

The revealed sale price is adjusted to 2016 real price (2016 CPI = 240.007). Over the study period, the data reveal that homes were sold on average for \$220,070. The average home age was 34 years old. The data capture homes built in the 19th century, as early as 1810, to the final year of the study period, 2016. The average square footage of homes is 1,842 linear feet; the average story of homes is about 1.4 units tall; the average number of fixed bathrooms is 2 units; the average number of half bathroom is a half unit, and the average property acreage is 0.22 acres. 64% of homes have attached garage, followed by homes with detached and no garage, respectively at about 15% and 14%. In terms of the month factor, most of the sales occur proportionally in the months of June, July, August, May, and August. Sales of residential properties are the lowest in the months of January, February, and December. From the sale's year categorical analysis, about 26% of residential transactions occurred during the peak years of 2004 (at 9%), 2005 (at 9%), and 2003 (at 8%). Year 2010 (at 3%), 2011 (at 3%), and 2012 (at 4%) encountered the lowest sales frequencies in the data. This paper expects that the structural variables of square footage, story, fixed and half bathrooms, property acreage, and attached garage will

positively increase the average home price. On the other hand, I expect that older homes and slow sale months and years will adversely affect the house price, a negative relationship.

## **B. Neighborhood Attributes Data**

The neighborhood characteristics data, which are integrated to explain community forces and socioeconomic patterns, are merged with the County map and residential data through the QGIS package. The neighborhood data were collected from multiple sources, including the US Census Bureau and Lexington Fayette-Urban County Government (Lexington opened data portal). Information on the median household income at the Census Tract level is provided by Social Explorer, a database which provides demographic data for the United States. Note: the original source of the median household income is attributed to the US Census Bureau and American Community Survey. Because willingness to pay for a utility is subject to income constraint, the median household income is a proxy that represents the household income in adjusted inflation dollars. Median household incomes are calibrated to year-2000 adjusted price for incomes between 2000 and 2009, and to year-2010 for incomes between 2010 and 2016. The data analysis shows that the average median household income was \$56,667 for Fayette County, Kentucky, as linked to the study period.

14 Zone Improvement Plan (ZIP) coded areas, which also serves as a proxy for neighborhood influences on households, are included in the study. Although ZIP-code areas are primarily used in an effective mailing system, a ZIP area might control for aspects such as the socioeconomic pattern, population, and crime rates that are associated with

residential households. The proximity of a home within a 0.096-km radius of a water network is constructed to reflect residential property's waterfront amenities. My waterfront control does not separately describe if the water network is a branch, creek, tributary, run, or fork. Through the established radius, the data show that 92% of the residential sales may not have access to waterfront amenities, while 8% of homes might enjoy the benefit of waterfront amenities. I find that waterfront properties sell above the average real price than non-waterfront properties. The ZIP and waterfront information were freely collected through Lexington's open data portal. The Portal, aimed at promoting high-value government data, is a collaborative effort between Lexington Fayette-Urban County Government (LFUCG) and the Fayette County, Kentucky community.

Information on the accompanying elementary school districts presents lagged data of 33 public elementary school districts in Fayette County, Kentucky over the four years. That is, from 2011/2012 academic year to 2014/2015 academic year. The school district data were openly collected through Fayette County Public School (FCPS). I structured the elementary districts into three performance levels, namely Distinguished, Proficient, and Needs Improvement. The performance levels are based on test scores percentiles. Test scores are accumulated from the reading, mathematics, social studies, writing, and language mechanics tests. The Distinguish level is classified on FCPS metric of 90 to 100 percentiles; the Proficient level is classified on the FCPS metric of 70 to 89 percentiles, and the Needs-Improvement level is classified on 0 to 69 percentiles. In this study, I construct the average performance levels by calculating the average percentiles over the lagged academic years. Hence, the performance levels of elementary school districts are used to explain the influence of schools on potential homeowners. Roughly, in the data,

21% of residential sale was transacted in the Distinguished districts, and 34% and 45% of sales occurred in the Proficient and Needs Improvement districts. Conforming to my expectation, homes in the Distinguished districts sell above average price than homes located in Proficient and Needs-Improvement districts. I hypothesize that high-performing schools or elementary district with higher percentiles will positively influence residential prices.

### **C. Parks and Historic Districts Data**

Information on my variables of interest, park and historic district, in a similar manner, was collected and constructed through Lexington's open data portal and Lexington Parks and Recreation. These sources are organs of the Lexington government. The data include 95 parks in Lexington, Fayette. The statistics in Table 2.1 show that the average distance of residential homes to a park in the county is about 1.8 kilometers. The closest distance to a park is 0.02 kilometers, and the farthest distance is recorded at 18 kilometers. Homes are approximated to the nearest park using the Nearest Neighbor (NN) plugin in QGIS. To account for park heterogenous preference, I include covariates of park type, if the park is a lease or own park, park acreage, and if the park contains a playground. This study also controls for if the park contains community, aquatic centers, and athletic field; if the park is designated as a dog-friendly park and contain recreational trail if any. My data include 13 community, 10 neighborhood, 5 golf-course, 1 historic park, 3 minis, 4 national/Greenways, 4 special-use, and 2 state-owned parks.

In an effort to facilitate the empirical strategies, the data are stratified into two groups to investigate the use-value of parks, see Table 2.2. Homes that have direct access

to a park, i.e., share a common fence with a park, are the treatment group. Homes located across the street, i.e., directly opposite the access-to-park-homes, make up the control group. 678 residential transactions in the data meet the observed criteria of matched covariates between the treatment and control groups. Homes with access to parks have an average real price of \$223,552, while homes located across the street have an average price of \$210,692. The average price of homes that are immediately around parks is \$218,412. The ages and median household income remain the only variables that are statistically different between the groups.

Data on the historic district were freely obtained from Lexington Parks and Recreation website. I included 17 local historic districts, scattered throughout Fayette County, Kentucky. 683 residential transactions, accounting for approximately one percent of sales between 2000 and 2016, are recorded in these local historic districts. A dummy is established for whether a home is in a historic district. This action allows for residential homes within historic districts to be compared to homes located outside local historic districts. Up to this moment, the data analysis shows that homes in historic districts sell far above the average price of homes outside designated districts. Following Clark & Herrin (1997), I interact house age with the historic dummy to control for an unbiased historic influence on the home price. To account for the spillover effect of historic districts, I established a binary variable, capturing a two-block radius (0.16 km) around historic neighborhoods. 446 homes were sold within the two-block radius over the study period, 2000 to 2017.



## VI. Econometric Specifications

My empirical model, as defined by the hedonic function, applies a semi-log functional specification to address misspecification bias, Clark & Herrin (1997), Leichenko et al. (2000), Cropper *et al.* (1988), and Kuminoff *et al.* (2010). With the same intention of addressing misspecification bias, I aim to control for endogeneity through the semilog functional form. Hence, I regress the logarithm of the real price on the structural characteristics, neighborhood and environmental attributes, and time variables to accurately evaluate the willingness to pay for parks and historic districts. My general covariate approach computes

$$\log P_i = \beta_0 + \beta_1 E_i + \beta_2 H_i + \beta_3 N_i + \beta_4 T_i + \varepsilon_i \quad (7)$$

where  $\log P$  is the dependent variable, denoting the real price of sale for household  $i$ . The real price is expressed in a logarithmic form to measure and interpret price elasticity.  $H$  is the vector of structural characteristics, enveloping house age, square footage of the home, story, fixed and half bathrooms, garage type, and property acreage.  $N$  reflects the vector of neighborhood characteristics, including median household income, the performance level of elementary school districts, proximity to a waterfront amenity, and ZIP-code area;  $E$  is the vector of the environmental attributes of interest, park and historic district.  $T$  is a vector representing the time dummies of the sale's month and year. Recall, controls for park include the park type, the feasibility of lease or own, park acreage, and whether the park contains a playground, community or aquatic centers, field or court, dog park, or a recreational trail.  $\beta$  depicts the parameter estimates and  $\varepsilon$  assumes that the Gauss-Markov conditions are treated by the data and the functional form.

$$\log P_{ijk} = \beta_0 + \beta_1 \rho_i + \beta_2 \pi_{ij} + \beta_3 \rho^2_i + \beta_4 S_k + u_{ijk} \quad (8)$$

Subscribing to this general model in Equation 7, I designed a specific model, Model 1. I employed a covariate stepwise approach to Model 1 to evaluate the influences of parks and historic districts on residential homes. The judicious inclusion of covariates in Model 1 accounts for the implicit prices and the robustness of the coefficients. However, a caveat of the covariate approach is that the introduction of controls could exacerbate endogeneity in the hedonic model.  $\rho$  depicts the distance of household  $i$  to a park, and  $\pi$  depicts if the household is in a historic district  $j$ .  $\rho^2$  accounts for the quadratic relationship of distance,  $S$  represents the spillover effect of a historic district in neighborhood  $k$ , and  $u_{ijk}$  controls for unobservable errors. Considering the stepwise approach, first, I control for a time fixed effects; second, I control for housing characteristics; third, I control for neighborhood fixed effects; fourth, I account for school fixed effects, and fifth, I control for park amenities fixed effects.

Finally, employing separate hedonic models for parks and historic districts, I built a boundary design specification for Model 2 and 3.

$$\log P_i = \beta_0 + \beta_1 \rho_i + \beta_2 x_i + e_i \quad (9)$$

Model 2, as projected in Equation 9, is the boundary design specification for parks. Equation 9 compares the geographic split between the treated areas, homes that have direct access to parks, and the control areas, homes that are located across the street.  $\rho$  is the treatment dummy if house  $i$  has direct entry to a park.  $x$  is the vector of covariates and  $e$  controls for random errors.

$$\log P_i = \beta_0 + \beta_1 \pi_i + \beta_2 x_i + e_i \quad (10)$$

Equation 10 attempts to capture the causal effects of the willingness to pay for historic districts. Under this design, the treated areas are homes located within the 17 local historic districts in Fayette County, Kentucky. Homes near the local historic districts, within a 0.16 km radius, are the control areas.  $\pi$  = the treatment dummy if a house is in a 2-block proximity. Model 2 and 3 also incorporate a stepwise approach for the inclusion of covariates.

A uniting force, combining park and historic districts into a single model in this study, is the testimonial of controls. The hedonic model, which is commonly used to investigate the values of parks and historic districts, demands the inclusion of independent variables or attributes that are of interest. Studies on parks and historic districts usually include similar covariates, including structural and neighborhood characteristics. In the spirit of capturing controls that are necessary to consider for the variable of interest, Kuminoff *et al.* (2010) highlighted: Neighborhood characteristics that matter to households but are not observed by the econometrician, are often expected to be correlated with the amenity of interest or other independent variables. Clark & Herrin (1997), focusing on historic districts, emphasized that the success of the historic district is strongly predicted by the characteristics of the neighborhood. Therefore, I combine parks and historic districts in a single study to controls for covariates that are important for parks valuation, when influenced by a historic district, and vice versa. That is, investigating historic district influence on residential property values when a nearby park is a dependent factor. Technically, Model 1 captures the combined effects, while Model 2 and 3 parallelly resign to respectively focus on parks and historic districts. The combination of environmental

variables might be necessary to research, if the context of the study encompasses and prioritizes amenities of parks and historic districts, like urban-rural Fayette County, Kentucky.

## VII. Result

I applied the hedonic analysis, regressing real price on the structural, neighborhood, and environmental characteristics of homes, to estimate the willingness to pay for parks and historic districts. Model 1, 2, and 3 results are presented in Table 2.3, 2.4, 2.5, and 2.6. I checked all empirical specifications to control for the Gauss-Markov error conditions. On average, all models used in this essay satisfied the no-multicollinearity assumptions. Illustratively, the average Variance Inflation Factor (VIF) of the models ranged from 1.62 to 3.89. The models' average VIF(s) are below the thumb-rule factor of 10. In cases where the VIF for a variable is greater than 10, I retained the highly collinear variable so as to avoid upward biases in the estimators. For example, squared distance to the nearest park was retained, despite being highly collinear, to explain the quadratic relationships. Moreover, I use the Ramsey's Regression Equation Specification Error Test (RESET) to examine if my functional forms are specified and freed of omitted variable bias and to point out issues of heteroskedasticity. In accordance with Godfrey *et al.* (1988), I expect that the Ramsey test is a good instrument to determine the best functional form since the test is swayed by normality and non-normal errors. Ramsey test, diagnosed on my models, rejects the null hypotheses that the models have no omitted variable bias, or the models do not suffer functional form specifications. Each model has a p-value of 0.0000 which is less than 0.05 significance level. This result points out that the functional forms, relative to study's data, do not accurately specify the hedonic model. Bootstrapping the models, to

control for misspecifications, I employ the robust statistical variance treatment to my estimators. The robust treatment invalidates the analysis of variance (ANOVA). Yet, the robust statistical variance treatment explains the significance of the estimators at the p-value of 0.05, 0.01, and 0.001.

### **A. Park Hedonic Results**

Column (1) through (7), presented in Table 2.3, report findings from Model 1. Model 1 incorporates a covariate semilog specification which builds on a stepwise approach, interpreting the estimates of parks and historic districts as elasticities. The coefficients of nearest distance to a park are positive and statistically significant at 0.1% in (1) to (7). Column (1) finds that as residential homes move a kilometer away from parks, the values of homes increase by 7%. I find a similar report in Column (2), when I control for time fixed effects of sales months and years. Evident in Column (3), the structural characteristics of homes, such as the property acreage, fixed bathroom, and garage type, play a significant role in influencing the estimate of the distance to the nearest park. Given the structural attributes, the price elasticity of distance to the nearest park decreases by 57%. Resultantly, the coefficient of the distance to a park influence on residential sale's price is 3%, as homes move a kilometer away. Controlling for neighborhood fixed effects in Column (4), the coefficient decreased from 3% to 2%. School districts' impact on a house induces an effect of 50% decrease in the nearness to park estimate, decreasing from 2% to 1%. Column (6), controlling for park amenities fixed effects, shows a 100% increase in the coefficient from Column (5). Here, as residential homes move a km away from a park, property value increases by 2%. Findings from Column (1) to Column (6) indicate that homeowners are

willing to pay a depreciated price to live close to a park, although their choices are not linear.

The final stepwise stage in Column (7) investigates the interactions between the nearest distance to a park and park amenities. Establishing these interactions is necessary to test if the implicit value of living in proximity to a park is interdependent on park amenities. We find an expected result in Column (7). Column (7) reports that as the nearest distance to a park increases, the estimated value is -0.11. This result implies an 11% negative influence on the values of homes, as these homes' distances increase from a park. With respect to park type, being statistically different from zero, as homes distances increase from a State-owned park, the homes attract a 3% increase in housing values relative to a community park. In addition, respectively, I find a 3%, 24%, 2%, and 13% increase in housing values, as homes are located away from a golf course, mini, special use, and State-owned parks. Living in proximity to a historic building and neighborhood parks, relative to a community park, influence negative values. Respectively and giving distance interaction, moving away from historic and neighborhood parks impact housing price negatively by 79% and 2%. Also, parks accessible-to-lease, relative to owned-parks, attracts a positive housing value for the average price at 14%, as homes distance away. With respect to recreational trails, I find that as the distance of homes increases from a park with a path and walking trails, homes' values are negatively influenced by 3% and 1%. With respect to other park amenities, I find that as homes distances increase from parks with playgrounds, their average housing value decrease by 2%; and as homes distances increase from parks with athletic fields or courts, their average housing value increase by 1%. These interaction terms indicate that historic, neighborhood, and community parks,

and amenities like path and walking trails, and playgrounds in parks attract positive use-values in parks. Contrariwise, the findings also suggest that golf-course, mini, special use, State-owned parks, and amenities like parks been leased and athletic field attract external costs or negative use-values and externalities in parks. Unlike specifications in Column (1) to Column (6), Column (7) implies, on average and considering the interdependencies with park features, parks are positively valued.

Model 1 is a naïve OLS regression. Model 1 might be vulnerable to empirical pitfalls suffered by OLS estimators. Acknowledging the caveats of a naïve OLS, I applied a park fixed effects specification to the model. Kuminoff *et al.* (2010) advised on the boosting of the parsimonious models by using a spatial fixed effect specification. However, there might be potential errors to unobservable spatial attributes which might be in the error term and could be correlated with parks and residential home prices, Livy & Klaiber (2010). The specifications presented in Table 2.4 include 95 parks in Fayette County, Kentucky for the spatial effects. Controlling for the parks fixed effects and time, structural, neighborhood, school, and amenities attributes, Column (1) in Table 2.4 shows that as homes distance increase in kilometers from parks, residential property values increase by 1%. I find an opposite effect when distance to parks are interacted park amenities, given park fixed effects. Therein, the findings showed an approximate 10% negative influence on the average price of homes, as homes locate away from parks. Column (1) in Table 2.4 suggests that, on average and taking into account the mentioned controls, parks have a negative use-value; whereas, Column (2) suggests that parks in Fayette County have positive use-value, given the interdependencies on park amenities.

The squared distance from a park provides evidence that is vital to explain the quadratic relationship of parks' influence on the price of residential homes, see Figure 2.4. As the average distance of a home increases from a park by an equal amount, the value of the home depreciates. This depreciation is the range of 0.02% and 0.04%. In monetary terms, parks quadratic relationship suggests that homeowners are willing to pay an average discount of \$400 as their distance from a park increase. In dollar value, the estimate ranges from \$440 to \$660, as the distance to a park increase by another kilometer.

To further investigate the mixed results from Model 1 findings in Table 2.3 and 2.4, I employed a boundary design estimator in Model 2 to estimate park hedonic valuation. Model 2, presented in Table 2.5, compares homes that have direct access to parks to homes that are immediately located across-the-street from parks. In a similar stepwise approach, I control for time fixed effects in Column (1), housing attributes in Column (2), neighborhood fixed effects in Column (3), and school and park amenities fixed effects in Column (4) and Column (5). Column (1) reveals a positive and statistically significant result, at 5% significance level, for the access-to-park dummy. On average, holding all things constant, and controlling for time fixed effects, residential properties that have direct access to parks sell at 10% above homes located across the street. This finding suggests a positive implicit value to have direct access to a park, which is valued at \$37,210. The report from Column (1) fails to reject my hypothesis that parks have a positive influence on the price of residential homes. This result indicates that homes utilize parks' amenities. Controlling for housing and neighborhood characteristics, school performance levels and park amenities fixed effects, Column (2) to Column (5) in Model 2 show no significant results. These findings in Column (2) to Column (5) imply that homes with direct access



to parks are not statistically different from home across the street from parks. The time fixed effects of sale month and year are the only factors that are likely to influence homes values in a close proximity to parks. In this case, structural characteristics, neighborhood, school districts, and park amenities do not influence the park valuation. Nevertheless, in terms of park amenities, I find that recreational trails are significant for the positive valuation of close proximity to parks, while athletic field negatively affects parks' values.

The findings in Model 1 provide mixed results to support my general hypothesis. Basically, I expected that parks have a positive impact on the residential homeowners. In part, the negative findings I report add to the argument which supports the mixed valuation of parks, McConnell and Walls (2005) and Livy and Klaiber (2013). Livy and Klaiber (2013) argued that disaggregating parks into amenities could provide an accurate estimate for parks. Livy and Klaiber suggest that the negative findings in the aggregate park value and park amenities are influenced by noise pollution, renovations that increase potential negative externalities (e.g., light renovation), and increased daytime activities.

## **B. Historic District Regressions Results**

Results from the hedonic estimates in Model 1, presented in Table 2.3, also present findings of the local historic districts. The effect of historic districts on home sale price is statistically different at 0.01% through Column (1) to Column (7) in Table 2.3. Column (1) presents that homes in designated areas sell at 30% above all homes in Fayette County, Kentucky. In monetary terms, the marginal willingness to pay for a historic district is \$66,020. Controlling for time fixed effects of sale month and year in Column (2), residential properties' values increase by 3% from (1); the value of residential homes in

local historic districts becomes 31% higher than the value of homes outside locally designated areas. Through Column (3) to Column (5), I find the highest willingness to pay for historic districts when controlling respectively for homes structural, neighborhood, and school attributes. These reports show a 51% increase in the average price for homes in local historic districts, valued at \$112,541. Column (3) to Column (5) demonstrate that structural, neighborhood, and the school factors, along with the impacts of designated areas, have strong influences on property values. Furthermore, when I control for park amenities' fixed effects on property values in (6), historic district estimate decreases by 25%. This change, by the inclusion of the nearest park features, sets the value of local historic district influence on residential homes to 38%. Herein, this impact, given park amenities controls, is valued at \$83,625. Lastly, in Column (7) of Table 2.3, the hedonic value of historic districts influence on homes is 39% greater than homes outside locally designated areas.

I also check in Model 1 for the effect of historic districts on the surrounding neighborhood. Findings in Column (1) and Column (2) do not show a statistically significant result. The findings in Column (3) through Column (7) indicate that homes within a 2-block radius of local historic districts sell higher than homes outside local designated in Fayette County, Kentucky. The values of these sales are respectively at 19%, 22%, 20%, 13%, and 15%. These results might suggest a spillover effect from historic districts on the immediate residential neighborhoods. I do not identify this scenario as gentrification. Clark and Herrin (1997) employed an analogous approach to measure historic district spillover effects. Clark and Herrin tested for historic district spillover effects on properties across the street and within a block of the historic boundary.

Model 3, reported in Table 2.6, compared homes in historic districts to similar homes in the 2-block neighborhood radius outside the historic districts. In a stepwise approach, I control for time fixed effects in Column (1), housing characteristics in Column (2), neighborhood fixed effect in Column (3), and school district fixed effects in Column (4). All results show that historic districts have a positive effect on housing price, indicating a positive impact of housing value greater than the surrounding neighborhoods. The historic district estimate is interpreted as 31%, valued at \$77,767. The historic district estimates, when controlling individually for housing characteristics in Column (2) and neighborhood fixed effects in Column (3), is changed to 0.26 from 0.31 in Column (1). In Column (2) and Column (3), the influence of historic district on housing price is the same: Local historic district increases residential home prices by 26% (valued at \$65,224). The introduction of school fixed effects in Column (4) increase the estimates of historic districts reported in Column (2) and Column (3). In Column (4), I find that local historic district influence properties' values by a 31% increase in the average sale price over surrounding residential properties.

Evident in Model 1 and Model 3, I fail to reject the hypothesis that historic districts have a positive influence on residential properties. Overall, the findings in Model 1 and Model 3 imply that historic district provides environmental benefits, as well as public and private incentives. My study supports the argument that historic districts have a net positive impact on property values, substantiating the findings of Clark and Herrin (1997), Leichenko *et al.* (2000), and Coulson & Lahr (2005). These results covering local historic districts from the context of Fayette County, Kentucky also apply to local historic districts in the United States. Housing and neighborhood characteristics, as well as school district

effects, might shape the dynamics of historic districts across cities. Fayette County, Kentucky is an urban-rural environment. It would be subtle to use a large dataset from rural, urban-rural, and urban cities to estimate historic districts (i.e., local, State, and Nationally) influence on residential properties.

## **VIII. Discussion and Implications**

Results from the hedonic analysis, with application to environmental studies, provide implications for the use-value of environmental goods. Recall, environmental goods may not have a structured market to price their use-values. However, the environment can be valued implicitly through the housing market.

### **A. Parks: Mitigating Negative Externalities**

The use-value of parks remain a sensitive issue to private homeowners and the public who utilize parks. Assessing the performance and utilization of parks is also a sensitive issue with key authorities who maintain, fund, conserve, and study this type of green, Klaiber and Phaneuf (2010). Due to the mixed evidence of the negative and positive implicit values of parks in this study, including Walls (2005) and Livy and Klaiber (2013), I recommend that mitigation strategies should be designed to address the negative externalities linked to parks.

One of the mechanisms that can be used to obtain parks, embedded with positive externalities and rid of negative use values, is to conduct a use-value surveys or reviews research. Given Fayette County, Kentucky's residential market, the implicit result of park values may only apply to residential homeowners near a park. These results might be

limited in reflecting the overall public valuation of parks and attached features. Using surveys or reviews can help parks' authorities and key role players to redirect funding, develop projects, and maintain specific park types and amenities. The survey also allows for detecting and strategizing the mitigation of negative externalities in parks. By way of illustration, Lexington, Kentucky government's office of Park and Recreation is accumulating responses by means of face to face conversations, surveys, and public meetings to make a master plan for parks and recreation in Fayette County, Park and Recreation (2017). One of the intentions of these public engagements is finding out what people want in parks. Hitherto, Fayette County, Kentucky park authority has surveyed 952 households, categorizing their feedback into places, programs, and actions. Interestingly, the park authority integrates, into their survey, questions about household barriers to park. However, within the pillar of what people want, the authority could incorporate a fourth category, called negative park features and activities. Subsequently, by this action, mitigation strategies can be designed to address negative externalities associated parks.

The negative externalities encountered by private homeowners might be attributed to noise pollution, renovations that increase potential negative externalities and increased daytime activities. Private residents and park authorities can alleviate the indirect and unintentional negative effects of parks through the following strategies: Rallying to express views on issues that affect homeowners directly; calling the local authorities; lobbying for local ordinance to reinforce regulations to curb nuisance violations in and around parks; engineering infrastructures to lessen light or noise pollution, and redesigning parking strategies around parks vehicles. For example, homeowners could exercise free speech on parklands, in conformity with the first amendment right of free speech.

## **B. Historic District: Investment Analysis**

Findings, at least robust in the coefficient signs in Model 1 and 3, for local historic districts show that historic districts have a positive influence on housing value. This implies that benefits such as tax credits and positive neighborhood upkeep surpass the maintenance cost and hurdles associated with historic districts. These implications support the argument of shared economic security and incentives in historic districts. Tax incentive programs for historic districts is a strong positive force. The tax incentive program supports rehabilitation in historic districts by providing a 20% tax credit for the certified rehabilitation of certified historic structures, Historic Preservation Tax Incentives (2012). This benefit is instrumental in facilitating economic development in historic neighbors. Leichenko *et al.* (2000) the cause of preservation tax incentives since higher property values in historic districts also means paying higher property tax. Homeowners or sellers can also enjoy direct public benefits in historic districts. For example, the Technical Preservation Service of the National Park Service provides technical resources to assist and guide the maintenance of historic buildings. Locally, historic authorities also provide technical assistance to owners of historic properties.

My discussion does not emphasize the cost associated with historic districts. Nevertheless, I communicate important risks associated with historic districts. Even though the study results imply that the tax credit program for historic homes is effective, a homeowner might face the risk of unharmonized certification process and construction permits huddles. Secondly, risks might include neglected homes in the neighborhood, thus creating an ugly character of the historic district. Thirdly, less rigid regulations in historic districts could fuel disinvestments, delayed maintenance, and contribute to inappropriate

materials being used. Moreover, homeowners or sellers may have a conflict of interest in using modern materials or technologies versus sticking to certified materials for historic districts. A final risk could be renovation misconceptions among neighbors in a historic district.

Most studies, arguing against historic district settlements, have repeatedly claimed that historic districts promote gentrification pressures. For instance, Conde (2007) criticized and opposed the program of historic districts. Conde portrays historic districts as neighborhoods that discourage interracial integration and promote segregation, especially in favor of white families. Groups like the Virginia Land Right Coalition reasoned that poor people will be squeezed out of their communities because property values will increase, and tax benefits are illegal. A priori, there seems to be little or no disclaimer from historic district authorities on these claims. Illustratively, Lexington Preservation, via its website, communicates licensing, permit development systems, and review processes. Lexington Preservation neither has an established disclaimer to distance historic districts from the stained characterization of gentrification nor recognizable actions which demonstrate that historic authorities support equity for all potential homeowners, social integration, and lawful justifications. I recommend that the National Registry of Historic Places and local historic district authorities should openly revoke connections to gentrification.

## **IX. Conclusion**

Studies, local inhabitants, and public authorities usually support the conversation of green space. Parks and historic districts are green space amenities intended to endorse benefits

like recreational, public events, environmental sustainability, and private investments. Despite the positive utilities associated with parks and historic districts, these green spaces do face challenges. Investigating the implicit values of parks and historic districts, I employ a hedonic model. The log of the real sale price is regressed on the structural, neighborhood, and environmental attributes of homes to analyze parks and historic districts influences on the residential market. My empirical specifications are presented in three models. In these models, I use a stepwise approach for the inclusion of controls and a robust treatment for measurement errors.

Finding from the covariate approach reports a negative implicit value for parks. This result indicates that parks, hosting features, do have externalities which negatively affect the use-value of parks. Through the hedonic approach, it is evident that factors of sale month and year, and housing, neighborhood and environmental attributes do affect the magnitude of park valuation. When I interact distance to the nearest park with the park amenities, I find that parks have positive use-values. This result suggests that a park valuation is interdependent on its amenities. Following the covariate approach, I also measured the value for parks by comparing properties that have direct access to parks to properties that are located across the street. In this case, I also find a positive willingness to pay for parks, signaling positive use-values. Given the covariate and boundary design models, parks and the amenities hosted by parks have mixed valuation. Parks positive use-values are tied to the type of park and features like multi-purpose trails. Negative use-values might be caused by factors of noise, light pollution, and undesirable park usage, Livy and Klaiber (2010). Finally, I find that as homes double their distance from parks, the value of park increases. Findings from all models show that historic districts have a positive



value on residential properties above homes located outside the designated areas. The result is correspondingly true when I compare historic districts to other areas in Fayette County, Kentucky. These findings imply strong positive environmental benefits and economic securities associated with historic districts. I also find a positive impact on homes in the two-block radius neighborhoods surrounding designated areas. I implicate this finding to a spillover effect of the historic districts on the surrounding neighborhoods.

I discussed mitigation strategies to address the negative effects and externalities of parks. I recommend that parks' authorities intentionally use surveys to detect and to mitigate negative parks externalities and improve undesirable facilities; private owners in proximity to parks should voice, report, and channel grievances from park nuisance to local authorities. In terms of designated districts, I discussed the positive benefits of investing, either as a homeowner or seller, in the historic district residential market. I also highlight risks that might impede benefits and investments in historic areas. Chiefly, I recommend to National, State, and local historic authorities to adopt communications and interventions that could directly address gentrification and actions that could prove that historic district stands for societal, environmental, and economic integration.

## X. Tables

**Table 2.1. Summary Statistics of the Continuous Variables of Structural Attributes and Distance to Parks**

Variable	Obs.	Mean	Std. Dev.	Min	Max
Price (real dollars)	64,727	\$220,070	\$150,730	\$16,202	\$5,591,398
House Age (years)	64,727	34	25	0	206
Square Footage (linear feet)	64,727	1,842	749	416	10,762
Story (unit)	64,727	1.4	0.4	1	3
Fixed Bathroom (unit)	64,727	2	1	1	10
Half Bathroom (unit)	64,727	0.5	0.5	0	4
Property acreage (acres)	64,727	0.22	0.18	0.002	9.75
Nearest Park Distance (km)	64,727	1.8	1.44	0.02	18
Median Income (dollars)	64,727	\$56,667	\$20,253	\$12,288	\$16,8103

**Table 2.2. Comparing Residential Homes that have Access-to-Park to Homes located Across-the-Street**

Variable	Access to Park (Treatment Group) 407 Homes	Across from Park (Control Group) 271 Homes	T-Statistics (Pr( T  >  t )
	Mean	Mean	p-value
Real Price (dollars)	\$223,552	\$210,692	0.1857
Age (years)	25	29	0.0079*
Square Size (square feet)	2,008	1,924	0.1431
Story (unit-feet)	1.5	1.5	0.0769
Fixed Bathroom (unit)	2	2	0.2580
Half Bathroom (Unit)	0.3	0.3	0.8587
Property acreage (acres)	0.19	0.19	0.311
Median Income (dollars)	\$60,324	\$55,424	0.0003*

**Table 2.3. Hedonic Estimates of Park: Findings of Distance to Nearest Park**

Dependent variable: Log of real price adjusted to the year 2016 (mean: \$220,067, Std. Dev: \$150,730)

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Nearest park	0.07*** (30.97)	0.07*** (30.99)	0.03*** (16.99)	0.02*** (6.84)	0.01*** (5.92)	0.02*** (9.32)	-0.11*** (-7.33)
Distance squared (km)	-0.002*** (-8.77)	-0.002*** (-8.42)	-0.002*** (-10.34)	-0.002*** (-4.81)	-0.002*** (-4.68)	-0.003*** (-9.86)	-0.004*** (-6.53)
Historic district	0.30*** (16.91)	0.31*** (17.41)	0.51*** (28.89)	0.51*** (24.12)	0.51*** (24.28)	0.38*** (28.92)	0.39*** (17.07)
Hist. (spill effect)	-0.07 (-1.67)	-0.06 (-1.64)	0.19*** (6.81)	0.22*** (9.74)	0.20*** (9.27)	0.13*** (9.14)	0.15*** (6.69)
Time FEs	No	Yes	Yes	Yes	Yes	Yes	Yes
House controls	No	No	Yes	Yes	Yes	Yes	Yes
Neighborhood controls	No	No	No	Yes	Yes	Yes	Yes
School FEs	No	Yes	No	No	Yes	Yes	Yes
Park amenities Fes	No	No	No	No	No	Yes	No
Distance to golf-course park							0.03** (3.11)
Distance to historic bldg. park.							-0.79*** (-8.73)
Distance to mini park							0.24*** (13.05)
Distance to neighborhood park							-0.02*** (-6.61)
Distance to national park							0.07 (0.01)
Distance to special use park							0.02** (2.73)
Distance to State-owned park							0.13***

**Table 2.3. (Continued)**

Dependent variable: Log of real price adjusted to the year 2016 (mean: \$220,067, Std. Dev: \$150,730)							
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
							(9.21)
Distance to a leased park							0.14***
							(10.12)
Distance to park with path trail							-0.03***
							(-11.63)
Distance to park with shared trail							0.01
							(-0.79)
Distance to park with walking trail							-0.01***
							(-4.30)
Distance to a park with playground							-0.02***
							(-7.13)
Distance to park with comm center							-0.02***
							(-1.14)
Distance to park with pool							0.01
							(0.08)
Distance to park with athl. Field							0.01***
							(4.64)
Obs	64,727	64,727	64,727	64,727	64,727	64,727	64,727
R <sup>2</sup>	0.02	0.04	0.69	0.75	0.75	0.76	0.76

Note: Significant at t statistics: \* p<0.05, \*\* p<0.01, and \*\*\* p<0.001. Column (1) to Column (7) represents a semi-log specification.

**Table 2.4. Hedonic Estimates of Park: The Inclusion of Park Fixed Effects to Nearest Distance**

Dependent variable: Log of real price adjusted to the year 2016 (mean: \$220,067, Std. Dev: \$150,730)

Variable	(1)	(2)
Nearest park (km)	0.01*** (4.16)	-0.06** (4.17)
Distance squared (km)	-0.002*** (-4.81)	-0.003*** (-4.97)
Historic district controls	Yes	Yes
Park FEs (n = 95 parks)	Yes	Yes
Time FEs (n <sub>year</sub> =17; n <sub>month</sub> =12)	Yes	Yes
House controls	Yes	Yes
Neighborhood controls	Yes	Yes
School FEs (n=3 levels)	Yes	Yes
Distance to golf-course park		0.07*** (5.38)
Distance to historic bldg. park.		-0.50*** (-5.12)
Distance to mini park		0.20*** (10.38)
Distance to neighborhood park		0.002 (-0.72)
Distance to national park		-0.1 (-1.06)
Distance to special use park		0.30*** (16.63)
Distance to State-owned park		0.08*** (5.53)
Distance to a leased park		0.8*** (5.53)
Distance to park with path trail		-0.03*** (-10.09)

**Table 2.4. (Continued)**

Dependent variable: Log of real price adjusted to the year 2016 (mean: \$220,067, Std. Dev: \$150,730)

Variable	(1)	(2)
Distance to park with shared trail		0.04*** (5.79)
Distance to park with walking trail		0.001 (0.52)
Distance to a park with playground		0.01*** (3.40)
Distance to park with comm center		0.04** (2.98)
Distance to park with pool center		-0.03 (-4.52)
Distance to park with athl. Field		-0.01** (-2.59)
Observations	64,727	64,727
R <sup>2</sup>	0.78	0.78

Note: Significant at t statistics: \* p<0.05, \*\* p<0.01, and \*\*\* p<0.001. Column (1) to Column (2) represents a semi-log specification.

**Table 2.5. Hedonic Estimates of Direct Access-to-Park: Boundary Design Regression**

Dependent variable Log of real price adjusted to year 2016 (mean: \$372,108, Std. Dev: \$138,408)					
Variable	(1)	(2)	(3)	(4)	(5)
Access to Park (dummy, default = Across-the-street properties)	0.10*	0.03	0.003	0.0001	-0.003
	(2.18)	(1.70)	(0.19)	(0.04)	(-0.16)
Time FEs (n <sub>year</sub> =17; n <sub>month</sub> =12)	Yes	Yes	Yes	Yes	Yes
House controls	No	Yes	Yes	Yes	Yes
Neighborhood FEs	No	No	Yes	Yes	Yes
Park amenities FEs	No	No	No	No	Yes
Observation	678	678	678	678	678
R <sup>2</sup>	0.04	0.78	0.85	0.86	0.87

Note: Significant at t statistics: \* p<0.05, \*\* p<0.01, and \*\*\* p<0.001. Column (1) to Column (5) represents a semi-log specification.



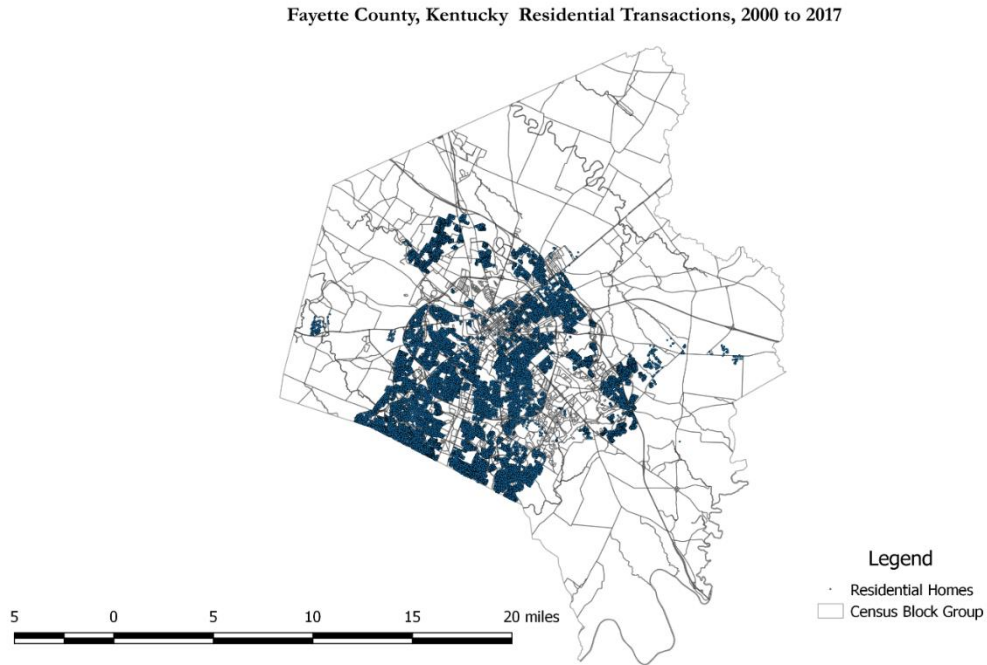
**Table 2.6. Hedonic Estimates of Historic District using Boundary Design Regression**

Dependent variable Log of real price adjusted to year 2016 (mean: \$250,861, Std. Dev: \$141,244)				
Variable	(1)	(2)	(3)	(4)
Historic District (default = 2 block neighborhood)	0.31****	0.26***	0.26***	0.31***
	(7.07)	(8.20)	(8.82)	(8.17)
Time FEs ( $n_{\text{year}}=17$ ; $n_{\text{month}}=12$ )	Yes	Yes	Yes	Yes
House controls	No	Yes	Yes	Yes
Neighborhood FEs	No	No	Yes	Yes
School Fes	No	No	No	Yes
Observation	1,095	1,095	1,095	1,095
R <sup>2</sup>	0.12	0.61	0.66	0.70

Note: Significant at t statistics: \*  $p < 0.05$ , \*\*  $p < 0.01$ , and \*\*\*  $p < 0.001$ . Column (1) to Column (4) represents a semi-log specification.

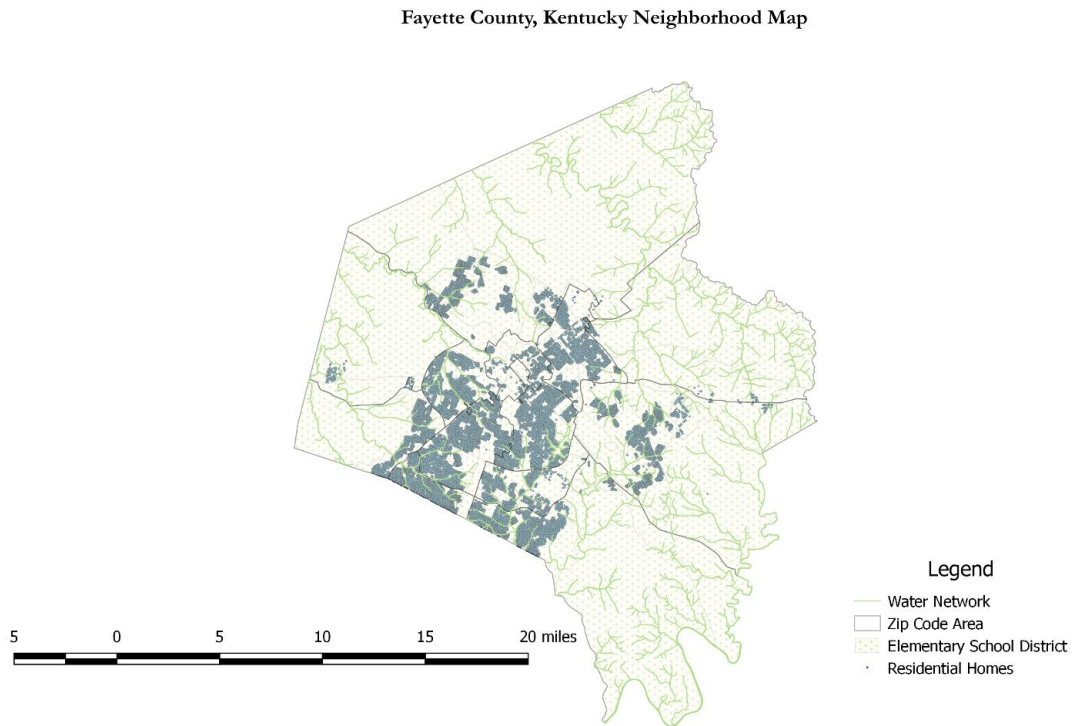
## XI. Figures

**Figure 2.1. Fayette County, Kentucky Residential Transactions, 2000 to 2017**



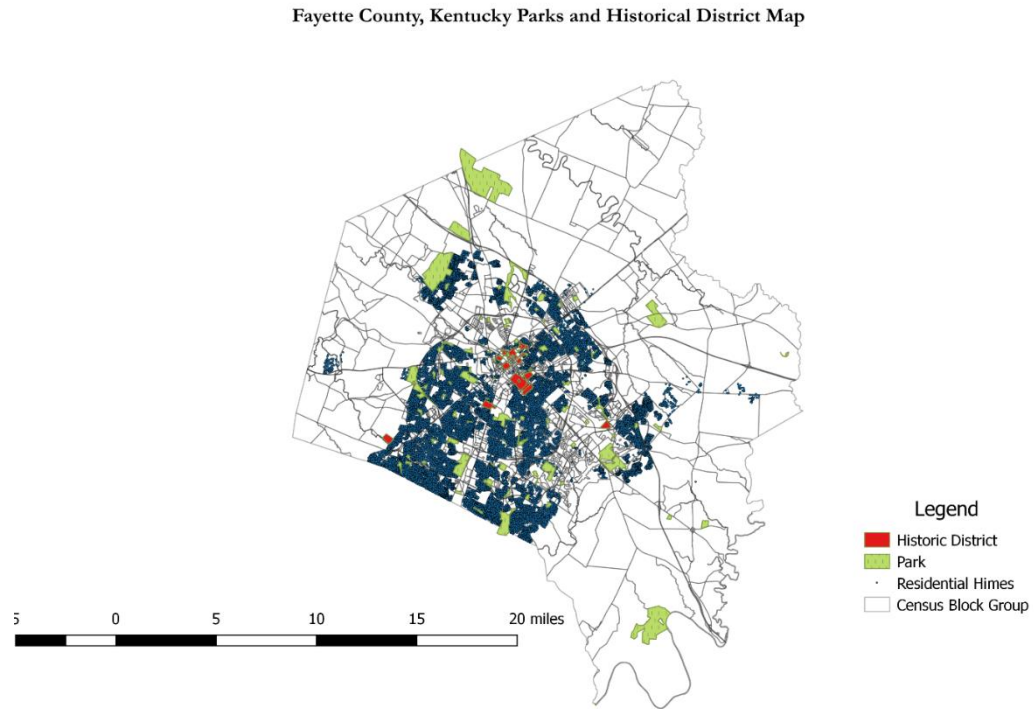
**Figure 2.1:** The map depicts the cluster of homes sold in the study period, between 2000 and 2016, embedded in Fayette County, Kentucky Census Block Groups.

**Figure 2.2. Fayette County, Kentucky Neighborhood Map, 2000 to 2017**



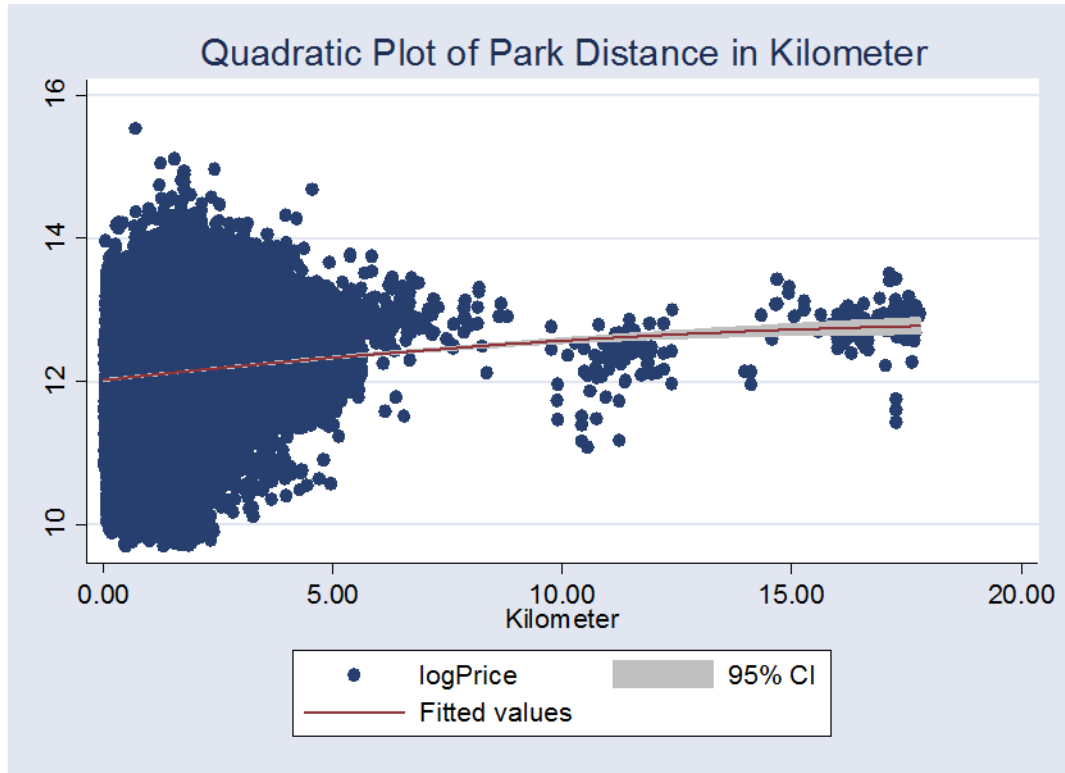
**Figure 2.2:** The map shows the clusters of homes in Fayette County, Kentucky over the study period linked to the neighborhood attributes of ZIP areas, elementary school districts, and waterfront amenities.

**Figure 2.3. Fayette County, Kentucky Parks and Historical District Map, 2000 to 2017**



**Figure 2.3:** An illustration of residential home sales in Fayette County, Kentucky around my variables of interest, parks and historic districts, over study dimension, 2000 and 2016.

**Figure 2.4. Quadratic Plot of Park Distance in Kilometer**



**Figure 2.4:** A quadratic plot demonstrating the relationship of the implicit value for residential homes, as the homes average distance increase from the nearest park. Distance is measured in kilometer (km) and shown on the horizontal axis.

## **CHAPTER THREE: WILLINGNESS TO AVOID LEAD RISK IN WATER**

### **QUALITY: ARE THERE INFORMATION ASYMMETRIES?**

Most Americans have access to water, yet America faces water challenges including lead contamination. My research asked questions about potential lead risk and lead-risk information asymmetries among homeowners. Using data from the Property Valuation Administrator in Fayette County, Kentucky, I answer the research questions through the application of hedonic analysis. I find an implicit positive value to avoid lead risk. I also report that buyers in high-lead risk neighborhoods might be less informed. I recommend to States and local authorities to periodically communicate lead risk to the public.

## I. Introduction

The United States access to water is rated at 99.26%, yet America is constrained with water quality assurance, pointing to risks of lead in the water supply systems. Accordingly, a quality water supply should be freed from meaningful physical, chemical, biological, or harmful radiological substances, including lead contamination. The Environmental Protection Agency (EPA) regulations set lead concentration to be less than 15 parts per billion (ppb) in a sampled 10% of a water zone. EPA revealed that nine States are reporting safe lead levels in their water supplies. However, about 5,300 States' water systems might be in violation of the lead rules, and there is a lack of residents' trust when it comes to reporting, testing, and treatment for lead contamination in water supplies, CNN (2016). Residents could possess elementary knowledge about lead contamination, but they might not be certain in determining the level of lead in their drinking water. The specific problem lies in the identification of lead contamination in a community water supply. The risk of lead in a water system can be certainly identified or can be challenging to detect. In a certain case of lead-risk identification, some counties in America report with confidence that their geographical subdivisions have no known lead risk and other counties confirm lead contents in their water supply. On the gray front, some counties cannot point out if their homes, water meters, water treatment and distribution systems contain lead materials.

Given this background, I ask the following questions: How does lead exposure risk in a water supply system affect housing values? Is there a presence of information asymmetries among homeowners relative to lead in their water supplies? I hypothesized that residential homeowners will pay more for lead-free water. I expect that homeowners in the high lead-risk water areas might have little information on their water supply

compared to low-lead exposure neighborhoods. I assume asymmetric information in high-risk areas because water lead-risk is not required to be reported during home sale transactions. Besides, real estate experts observe that a water problem is frequently concealed above all other home disclosures, Gasset (2016). In this study, I hope to measure the influence of lead-risk level on residential home sale transactions and to communicate policy implications for homeowners, home sellers, and policymakers to address the concern of lead-risk in the water systems.

This paper's contribution to the water quality literature lies in assessing the hedonic valuation of a probable lead risk in drinking water and searching for the possibility of asymmetric information. The literature on water hedonic pricing ranges from valuing surface water to pricing water through the land market. Other studies, not using hedonic analysis, have also evaluated the willingness to pay for municipal water supply and drinking water quality. Leggett and Bockstael (2000) used hedonic analysis to demonstrate the effect of water quality on waterfront properties in the Chesapeake Bay area. Using eight empirical specifications, Leggett and Bockstael reports show that as bacteria level increase in the Bay, property values reduce by 5%. Buck *et al.* (2014) also contribute to this paper through their supportive argument that a stable market can be used to infer the value of an environmental good. Piper (2003) evaluates the impact of water quality on municipal water price and residential water demand. Piper's results support the argument that households appreciate an improved water quality system. Powell & Allee's (1990) results, from a contingent valuation survey carried out in four towns in Massachusetts, show that people are willing to pay more for drinking water quality, especially when they have experienced contamination harms. Jordan & Elnagheeb (1993) find that 23% of households were



uncertain of their drinking water quality. Trending studies are addressing the general course of lead in the national water supply. Theising (2017) is discussing “Lead pipes, prescriptive policy and property values, lead pipes and prescriptive policy”; Irwin (2017) on “Homebuyer risk perception in the face of potential lead exposure”, and Grooms *et al.* (2017) on “Drinking water and lead: Evidence from local treatment changes in North Carolina”.

The theoretical framework of this essay is underpinned by the hedonic theory. Rosen (1974) presents that goods are valued for their utility bearing attributes. A class of differentiated products has a vector of measurable characteristics which define a set of hedonic prices. I assume the housing market is a differentiated product market, which has a bundle of characteristics. Residential homes host characteristics like square feet, structural design of the home, being close to an environmental amenity or being linked to a certain water quality zone. Overall, the theory calls for information on the structural characteristics, neighborhood and environmental attributes, and other controls to capture implicit price effects. I depart from Rosen on the assumptions of no second-hand market and the perception of identical characteristics. Akerlof’s (1970) theory debated on quality in the market. He pointed out good and bad qualities in market mechanisms and argued that rational consumers will demand better quality. To carry out the hedonic analysis, my dataset merges information from Fayette County, Kentucky Property Valuation Administrator, Vox Media, and other sources like Census Bureau. The study period covered a 17-year period (2000 to 2016) and included 70,619 sales transactions that occurred in Fayette County, Kentucky. To evaluate the willingness to pay for lead risk in the water quality supply, I applied empirical specifications of ordinary least squares, two-

stage least squares, and propensity score matching. To check for asymmetric information, I constructed a deterministic model, advised by Kurlat and Stroebel (2015), to test for differences between appreciating rates in the low and high lead water risk zones.

In this paper, Section 2 presents the problem of lead contamination in water supplies and the specific problem of identifying lead risk in water communities. Section 3 provides a review of the hedonic literature, water quality papers, and hints on trending studies in the case of lead in the United States. Section 4 describes the theories that support the study and the data is described in Section 5. I examine the research questions in Section 6 through the empirical specifications, including a deterministic test. Section 7 shows the findings from lead-risk influence on the residential market and reports the test of the deterministic model on asymmetric information. Finally, Section 8 gives a summary, provides implications, and suggests a way to improve the study's gaps.

## **II. Background**

Global water supply is very important to every region of the world, as water supply issues sprout from health to environmental concerns. For example, despite North America, including Canada, accessibility level of water is above the global average of 90.7%, the United States face challenges of water allocation and quality. The alarming risk of lead level in drinking water is one of the water quality challenges. According to the Safe Drinking Water Act (SDWA), a quality water supply is free from meaningful physical, chemical, biological, or harmful radiological substances. Relative to the risk of lead contamination, the United States Environmental Protection Agency (EPA) regulates that

the lead concentration in public water systems must not exceed an action level of 15 parts per billion (ppb) in more than 10% of customers' tap samples.

In March 2016, CNBC News article published: America's water crisis goes beyond Flint, Michigan... impacting millions of lives and costing billions of dollars in damages. The new wave of lead awareness reverberates the need for financing and investing in the Nation's water infrastructures to protect citizens from serious public health dangers. EPA disclosed that only nine States are reporting safe levels of lead in their water supplies. These States include Alabama, Arkansas, Hawaii, Kentucky, Mississippi, Nevada, North Dakota, South Dakota and Tennessee. 5,300 States' water systems, supplying about eighteen million Americans, are believed to be in violation of lead rules. From a residential viewpoint, homeowners have expressed a lack of trustworthiness in the reporting, testing, and treatment for lead contamination in water supplies CNN (2016).

Residents may have basic knowledge about how one can be exposed to lead contamination, but homeowners might not know the levels of lead in their drinking water. Sometimes, through macro-observation, residents can easily point out that their water supply is contaminated. For instance, when the city of Flint, Michigan switched to the Flint River for supply, residents noticed and complained about the discolored water. Besides, respectively, pediatricians and independent studies noticed the high level of lead in children and the local water supply, Jordan (2016). Locating lead pipes, which cause contaminations in communities' water supplies, can be a challenge. The central problem lies in identifying water services or supplies that are contaminated by lead. Identifying whether water supplies are contaminated by lead can be a certain case or a gray area between certainty and uncertainty. In the case of certainty, some counties in the Nation report with confidence

that their geographical subdivisions have no known lead contents in their water services, while others confirm lead contents in their water services. Illustrating the former on the certainty of no lead contamination, a few counties in Southwest Ohio, namely Butler, Englewood, Fairborn, Fairfield, and Green counties, report no lead contamination in their water services. These counties are certain, claiming meters were replaced; their communities contain only iron, copper, and plastic pipes; new developments and buildings were constructed after 1998, and their water treatment and distribution systems were created after 1957. Regarding the latter certain case on confirmed lead risk, some counties in the region have validated the presence of lead risks in their areas. Herein, counties such as Miamisburg, New Carlisle, Oakwood, Oxford, and Sidney counties in Southwest Ohio confirmed lead services on the basis that their water supply connections and service lines in public and private properties contain lead in their water distribution systems. That is, there are proven lead lines, solders, fixtures, or goosenecks; and most homes were built between 1900 and 1950, and as far back as 1895. Counties like Piqua and Franklin in Southwest Ohio report their water systems as probable lead areas because of old developments, while lead pipes are being replaced, Driscoll (2017).

This study asks these research questions: What is the hedonic valuation of lead exposure risk in the water supply? Are there information asymmetries among homeowners relative to lead-risk in their water supplies? I expect that residential homeowners will pay more price for good water quality. I also expect, on average, homeowners in high-lead water exposure areas may have little information on their water supply compared to low lead exposure neighborhoods. The latter hypothesis assumes that asymmetric information is present, mostly for high-risk than low-risk areas, see Figure 3.1.

It is important to consider the effect of a probable lead risk on housing valuation due to the health concerns, environmental engagements, and decisions that are needed to finance the replacement of lead service lines and lead components in United States' water-communities. Lead contamination in the water supply is an aged infrastructure problem which is caused by older pipes that contain lead. Lead may enter water systems as it dissolves through lead-pipes when water passes through the distribution channels. One of the main sources of lead contamination is lead service lines that connect water mains to residential properties. Also, pipes within homes, soldered with lead, might contribute to lead contamination, as water sits idle in these pipes while the system is not in use in the home, Kentucky Division of Water (2017). In 1986, amendments to the drinking water act prohibited the use of the not-lead-free pipe, plumbing fitting, fixture, solder, or flux in public, residential, and nonresidential buildings. Not until 1996, it became unlawful for any person to introduce into the market any pipe, plumbing fitting or fixture which is not lead-free, EPA (2017) and Cornell Law School (2017). Lead toxicity gives rise to serious health defects in the human body. Most especially, lead harm is severe to little children. 10% to 20% of a lead intake in children is caused when water, which is poisoned by lead, is consumed, Rabin (2008). Lead intake and accumulation promote weakened cognitive development in children, damage kidney function, produce cardiovascular problems, and negatively affect the brain, liver, and bones. In extreme cases, lead intake might result in death. In short, the presence of lead in a water supply can engender health risks to the public.

Financing the replacement of lead in public and private properties is a major mitigating, or better say, eradicating strategy in the United States. There have been

alternative financing approaches, designed or being proposed. Since 1996, the Drinking Water State Revolving Fund (DWSRF), a federal-state partnership, has promoted the financing of safe water systems in each State. Following the Flint, Michigan crisis in 2014, the White House pledged more than five-billion dollars to improve water quality in the nation. Today, Federal agencies such as CDC and EPA, tasked with tackling lead contamination, have experienced a fiscal year (FY) budget cut. For example, CDC encountered a 17% budget reduction in FY 2017/2018, counting a cut in areas of prevention, environmental health, and toxic substances, CDC (2017). In addition to financing mechanisms, a legislative bill is debating the provision of loans or grants to finance the removal of lead pipes. This Lead Act, LRB-1934, calls for authorities to be given to local governments for the provision of an opportunity and for a local water utility to provide financial assistance for replacing the lead service lines, Cowles (2017).

### **III. Literature Review**

This paper contributes to the water quality literature by assessing the hedonic valuation of a probable lead exposure risk in drinking water and to search for the possibility of asymmetric information relative to lead risk in the residential market. The literature on water hedonic pricing ranges from the surface water valuation of waterfront properties to pricing water through the land market. Other studies, not using hedonic analysis have also evaluated the willingness to pay for municipal water supply and drinking water quality. Together, these studies have considered and investigated the value of surface and groundwater quality amid water challenges. For instance, valuation papers have covered damages caused by sediments, bacteria, nutrients, and soil erosion-related pollutants in water networks such as streams, lakes, reservoirs, and estuaries. At the time of this

research, there are a series of forthcoming papers that are addressing the general course of lead in the national water supply.

### **A. Hedonic Valuation of Water Quality**

The attempt to understand the implicit valuation of environmental goods in a nonmarket scenario is a path I aim to build my analysis on. There may not be an explicit market to price whether homeowners place an appreciation or depreciation on their water quality. However, given this nonmarket scenario, the hedonic analysis is a tool that can tease out the willingness to pay for lead exposure risk. Leggett and Bockstael (2000) used hedonic analysis to demonstrate the effect of water quality on waterfront properties in the Chesapeake Bay area. Leggett and Bockstael influence the approach and analysis of this paper through their argued hypothesis that good water quality positively affects the values of residential properties. Accordingly, homeowners are expected to bid for prices of residential units which have a desirable level of characteristics, including water quality. It is expected that locals will be willing to pay an appreciated price for low exposure risk neighborhoods. The low-lead risk is certainly a higher environmental quality. The authors point out to a robust empirical work as a convincing factor in considering the significance of the environmental result. In this case, a robust empirical work means cleaning the analysis of ambiguities, such as functional form, and addressing market segmentation and multicollinearity. So, Leggett and Bockstael (2000) measured water quality, referencing waterfront amenity to properties, on the level of fecal coliform bacteria existing in the water. In their study, it was assumed that information on coliform bacteria is spatially and explicitly available to the public. That is, residential homeowners in the context of the study had symmetric information on the level of fecal in their surface water. This assumption is

vital to this paper because it sets the stage to picture the argument of information asymmetries. Leggett and Bockstael (2000) constructed eight empirical specifications to estimate the hedonic price using an ordinary least square (OLS) estimator. Within the scope of their study, Anne Arundel County, Maryland, Leggett and Bockstael find that an increasing level of bacteria in the Bay significantly reduces property values by 5%.

Buck *et al.* (2014) research also influence this paper, through their supportive argument, by using a stable market to infer the value of an environmental good; a reminder that the hedonic procedure is common to influencing environmental policies. Buck *et al.* use evidence from the land market to infer the value of irrigation water, an environmental nonmarket good. Unlike using the OLS cross-sectional data estimator, the authors support the application of a hedonic model that uses a fixed effect estimator. Besides, Buck *et al.* (2014) highlight the use of an instrumental variable model, as used by Kuminoff & Pope (2012) and Bishop & Timmins (2013), as an alternate approach which could consistently and comparably estimate the willingness to pay for an environmental good. This advice is adhered to, in my econometric section, as one of the robust estimators. Despite the uniqueness of the hedonic literature, other empirical models can be used to estimate the implicit value of water quality. For example, Bockstael *et al.* (1987) applied models of systems of demands, discrete choice, and hedonic travel cost to validate the willingness to pay for water quality.

## **B. Non-Hedonic Valuation of Residential Water Supply**

It is almost inevitable to argue against the premise that high-quality water supply is valued above low-quality water supply. This argument is also necessary to set the expectation



when measuring the impact of lead exposure risk in water quality on the residential market. An array of non-hedonic studies have evidently proven the vertical structure of water valuation. Piper (2003) evaluates the impacts and implications of water quality on municipal water price and residential water demand. Piper work assessed the extent to which a water quality influences residential water supply expense system and impacts the households' prices. Piper (2003) supports the arguments that households have a higher willingness to pay for improved domestic water quality. In the water-use model, Piper conclusion holds that poor water quality leads to higher treatment cost and higher water rates. Jordan & Elnagheeb (1993), Powell & Allee (1990), and Schultz & Lindsay's (1990) hypotheses also agree on the willingness to pay for an improved water quality. Jordan & Elnagheeb (1993) surveyed people's willingness to pay for improved drinking water quality and the perception of water impurity in their areas. Jordan & Elnagheeb, using the contingent valuation method in Georgia, find that 23% of households were uncertain of their drinking water quality. This finding is essential to communicate the presence of asymmetric information among residents in a water community. Powell & Allee's (1990) results, from a contingent valuation survey carried out in four towns in Massachusetts, show that people are willing to pay more for drinking water quality, especially when they have experienced contamination harms. Finally, demonstrating homeowners' willingness to pay for water quality, Schultz & Lindsay's (1990) results showed that both residents and the community were willing to pay a higher price for a hypothetical groundwater plan.

Forthcoming studies are equally addressing the environmental constraint of lead risks. Some of the impending studies include discussions on lead pipes, prescriptive policy and property values, Theising (2017); lead pipes and prescriptive policy: Estimating

homebuyer risk perception in the face of potential lead exposure, Irwin (2017); and drinking water and lead exposure: Evidence from local treatment changes in North Carolina, Grooms *et al.*, (2017).

#### **IV. Economic Model**

The core of the analysis in this paper revolves around the hedonic theory. In accordance with Rosen (1974), the hedonic hypothesis presents that goods are valued for their utility bearing attributes. Therein, the theory draws that a class of differentiated products, which has a vector of measurable objective characteristics, define a set of hedonic prices. The housing market, which has a bundle of characteristics, meets the assumption of a differentiated product market. Residential homes hold different characteristics such as square feet, structural design of the home, being close to an environmental amenity, or proximity to a certain water quality zone. Paramount to the theory is the argument of spatial economic equilibrium: A consolidated set of implicit prices guides both the consumers and producers' locational decisions in a characteristic space. Market equilibrium, a price clearing force which guides the decisions of both buyers and sellers, coordinate the implicit prices from a set of characteristics. Analyzing water systems' exposure to lead risk through the hedonic framework, the results will yield a hedonic price for lead exposure areas. The bundle of characteristics in the housing market includes structural, neighborhood, environmental and time attributes.

$$P = f(H, N, T, \dots, E) \quad (11)$$

Where,  $P$ , the market price is a function of the vectors of housing characteristics  $H$ , neighborhood attributes  $N$ , time effect  $T$ , and other utilities, including a vector of

environmental amenities,  $E$ . Although homeowners may subjectively value lead risk, according to Rosen, it is assumed that all homeowners perceive identical characteristics. Put in another sense, homeowners are knowledgeable about their water quality. It is also assumed that differentiated homes may also be sold in a separate, yet highly interrelated market.

On the producers' front, Rosen (1974) presents that producers carefully consider the package of characteristics to assembly in a locational decision. Residential home sellers want to equally minimize their factor costs and produce optimal utilities. Given the latter producer motive and arguing in favor of asymmetric information, some home sellers could conceal information such as the probable level of lead contamination in the water supply. Not intentionally, this action could be carried out in the spirit of minimizing cost and presenting optimal utilities to potential residential buyers.

$$P(z) = CM(M, H, N, \dots, E) \quad (12)$$

Equation 12 manifests that  $P(z)$ , the total cost of all attributes, is dependent on the function of positive and increasing cost  $CM$ , relative to the number of homes produced by a residential seller  $M$  and the assembled attributes, the vectors of  $H$ ,  $N$ , and  $E$ . For a market equilibrium to be satisfied, Equation 12 must be equal to a consumer bid function, as shown in Equation 13. Equation 13 is a value function where  $P(z)$  is the amount that consumers are willing to pay for attributes  $(H, N, \dots, E)$  at a fixed utility which is optimally chosen.  $\alpha$ , depicting optimally chosen, indicates that the utility bundles differ from household to household and utility depends on budget constraints, the household income  $y$ .

$$P(z) = U(M, H, N, \dots, E; \alpha, y) \quad (13)$$

In spite of the many inferences that can be achieved through the hedonic theory, the theory is clouded with assumptions and faced with empirical challenges. To name a few, empirical challenges related to the hedonic model include omitted variable bias, multicollinearity, choice of functional form, market segmentation, and attitude to risks, Leggett and Bockstael (2000) and Hanley *et al.* (2002). First, my empirical evidence of lead exposure could be potentially bias if my model omits a variable which is important to explain either the housing price or the lead risk variable. The variables incorporated in this study, relative to the structural, environmental, and neighborhood attributes, might be highly collinear. Thirdly, potential homeowners attitude to risks, such as avoiding crimes, less energy efficient homes, and environmental disamenities, could also introduce a biased estimate. Finally, choosing either a parsimonious or flexible functional form is affiliated with a benefit and cost. For instance, in terms of empirical benefits, traditional parsimonious forms like linear and logarithmic functions can have economic interpretations and be more robust to misspecification, Cropper *et al.* (1988) and Kuminoff *et al.* (2010).

My point of departure from Rosen (1974) is on the assumptions of no second-hand market and symmetric information. I disapprove the former assumption of no second-hand market in this paper because the residential market is not purely consumed. There is overwhelming evidence of resale homes in the residential market. On the latter assumption, Rosen assumes that although consumers may differ in their subjective valuations of differentiated packages, all consumers' perceptions or appraisals of a number of characteristics embodied is identical. In respect to the focus of this essay, I question the latter assumption and align my analysis with the theory of asymmetric information. Akerlof

(1970) logically discussed the uncertainty of quality in market mechanisms. Practically observing the housing market through the eye of Akerlof, there are homes with good and bad qualities. Rationally, consumers will demand better quality.

$$Q^d = D(P, \mu) \quad (14)$$

$$\mu = \mu(P) \quad (15)$$

$Q^d$  depicts the demand for homes;  $P$  depicts price, and  $\mu$  depicts water quality. In equilibrium, Akerlof assumed that supply equals demand for given average quality. Equation 15 depicts that the demand for water quality depends on price. Yet, Equation 14 and 15 may not hold true in the presence of asymmetric information. Relative to probable lead risk, a buyer may perform a housing transaction without knowing whether the home is located within a relatively low or high lead exposure zone. Even though it is possible to value lead exposure risk through the residential market, there might be a market failure of asymmetric information associated with the housing market. This market inefficiency might be attributed to hidden type model, wherein residential property sellers may have private information on the water supply that potential buyers are not knowledgeable of, Snyder & Nicholson (2008). However, over a length of time, homeowners may acquire a fair knowledge of the quality of their water supply. Knowing then the quality of their water, the home's resale may in part manifest the asymmetric information. Consequently, the null hypothesis establishes that homes in low-risk areas may sell cheaper or at the same price relative to homes in high-risk areas due to information asymmetries.

## V. Data

The hedonic function calls for information on the housing characteristics, neighborhood and environmental attributes, and other control variables in order to empirically capture the implicit price effects on residential properties. I collected information from multiple sources and joined the information through a Geo-information system (GIS) technique using the Quantum GIS (QGIS) software. Table 3.1 gives the summary statistics of the continuous variables of home, neighborhood, and environmental attributes used in this study. Considering the study period, the data cover 17 years, 2000 to 2016, featuring 70,619 sales transactions that occurred in Fayette County, Kentucky.

### A. Lead Risk Data in the Context of Fayette Kentucky

Fayette County, a Commonwealth county in Kentucky, encounters the same concerns of water challenges, including lead risks. Locals frequently ask questions about their drinking water quality like “Why do we have cloudy or milky water? Why do we have brown or yellow water? Is there lead in our water? What is the difference between hard and soft water?”, Kentucky American Water (2017).

“Because service lines, faucet fixtures, household pipes, and/or solder can contribute significantly to the lead and copper levels in tap water, we ask our customers to collect samples in their homes. These samples are collected on a routine basis (systems begin by monitoring once every six months with reductions in sampling possible that allow for monitoring once every three years) at homes that are considered vulnerable based on when they were constructed, and the materials used. We do this monitoring according to the requirements of the Lead and Copper Rule and use the results to confirm that our corrosion control strategy is operating as intended.”

This quotation is a statement from Kentucky American Water, revealing that the water system in Fayette County, or State at large, do encounter probable lead challenges.

Kentucky has an active program to address lead. The program contains laws and regulations on lead, including trainings, certifications, and investigations of lead complaints. Although the average water quality in Fayette County, Kentucky is relatively good, Fayette County, Kentucky presents an interesting variation in the study of lead contamination. I do not have an actual information on lead contaminants in the Fayette water systems. Nevertheless, this study uses an exogenous proxy called lead exposure risk, collected from Vox Media, to account for the lead in Fayette County, Kentucky's water supplies. Lead-risk zones in Fayette County, Kentucky, structured at the Census Tract level, varies from potentially low to high-risk areas, see Figure 3.2. Older neighborhoods in Fayette County, Kentucky are rated as highly probable exposure zones, while newer residential areas in the County are rated as low probable exposure zones. Homes in the older sections of Fayette County might have lead pipes and solders, yet the search and replace plan is undergoing, WKYT (2016). Vox teamed with epidemiologists from Washington State's Department of Health to estimate the risk levels in every geographic area of the United States. The data is originally calculated from the Census data. Similar to the United States, Fayette County, Kentucky is systematized into 10 lead-risk layers. In an ascending order, 1 represents the lowest risk area, while 10 represents the highest risk area. This exogenous proxy, lead exposure risk does not confirm that there is an actual lead contaminant in a water supply. Instead, lead paint, the age of the house, and the poverty rate are some of the attributing factors used by the researchers to construct the lead-risk variable and applied by this study to indicate lead risk in the water supply.

## **B. Housing and Neighborhood Characteristics Data**

Structural attributes data are necessary to control for the housing characteristics influence on residential homes. The Housing transaction data is accredited to Fayette County, Kentucky's Property Valuation Administrator (PVA). PVA collects and maintains residential property data, and track ownership changes and update changing characteristics of properties in the County. The PVA data provide information on home price, month and year of the sales transaction, the year the home was built, the building square feet, garage type, fixed and half bathrooms, and the property acreage. The sale price is the study dependent variable. I adjust this price to accurately reflect the current market value of homes, using 2016 consumer price index (CPI 2016 = 240.007).

The data analysis shows that homes are mostly sold at or above the average price during the months of May, June, July, August, and September. June and July are the peak months of sales. Respectively, about 11% of residential homes, over the study period, are sold in June and July and sold above the average inflated price of \$219,328. The slowest sales months in Fayette County, Kentucky are January and February. January contributes to the number of homes sold at 5% and February at 6%. Moreover, the peak sales in the county occurred during the years of 2003, 2004, and 2005, respectively at 8%, 8%, and 7%. These sales reveal the year fixed effects, as well as the relative economic times in those years. An additional structural description showed that about 64% of homes in the study period has attached garage, followed by homes with detached garage at 15% and homes with no garage at 14%.



Controlling for the neighborhood attributes, I collected data factors from the Lexington government, including Fayette County Public School System (FCPS). The data on neighborhood attributes were collected through the county's open access data portal. Presented in dichotomous variables, information on the neighborhood and the environment include if the home is located within a historic district if it located within 0.1 miles to a park, and if it is within 0.06 miles to a water network. Other neighborhood factors are the associated elementary school district boundary, Zone Improvement Plan (ZIP) area, and the household median income at a Census Tract level. There are 17 local historic districts included in the data. Being a place of cultural, historical, and environmental attractions, historic districts may provide benefits to residential homeowners in the form of higher property value and tax breaks. Homeowners in Fayette County, Kentucky also enjoy the amenities of about 100 parks. The features in these parks range from the types of parks such as community, golf-course, or neighborhood parks and recreational facilities like aquatic centers, and multi-purpose trails. I observe that approximately 10% of the homes in the data are waterfront properties. Waterfronts in Fayette County, Kentucky include creeks, runs, tributaries, folks, and branches. In the same spirit of neighborhood factors, I include 14 ZIP areas, about 33 elementary school districts, and the median household incomes of Fayette County, Kentucky to control for potential influences on buyers and seller's decisions. ZIP code areas give forth the linked socioeconomic factors of a neighborhood. Median income averaged at \$57,559, might depict homeowner preference, money constraint, and financial ability to address lead risk. The elementary school districts control for the associated performance level on residential properties. Measured by the average test score percentiles from 2011 to 2015, this study categorized the elementary

districts by their average performance levels into Distinguished (90 – 100 percentiles), Proficient (70 – 89 percentiles), or Needs Improvement (0 – 69 percentiles).

### **C. Analyzing Neighborhood Characteristics by Relative Lead Exposure Risk**

For further data analysis, the lead-risk exposure zones are organized into two groups for matching purposes. As shown in Figure 3.2, lead-risk level 6 to 10 are identified as neighborhoods having the highest probability of lead exposure. This is my treatment group, accounting for 37% of residential sales. Lead-risk areas in level 1 to 5 indicate areas with the lowest probability of lead exposure. This zone represents the control group, accounting for 63% of residential sales in Fayette County, Kentucky. At the 5% significance level, Table 3.2 finds that variables in the two groups, treatment, and control, are statistically different. For example, the average median income for homes in the high lead exposure zones is \$43,637 while the average median income for homes in the low lead-risk areas is \$65,722. Homes in the low exposure zone have an average age of 26 years, whereas homes in the high exposure zone have an average age of 52 years.

## **VI. Empirical Estimation**

The equilibrium economic phenomena, as presented in Equation 11, underpins my general model for the first phase of the analysis. In the first phase, I incorporate empirical strategies of covariates, two-stage least squares (*2SLS*), and propensity score matching (*PSM*). These methodologies allow for a comparable and robust analysis of the influence of lead-risk, relative to the water supply, on the residential market. My study second phase focuses on a sub-sample of a one-time resale of residential homes in Fayette County to check for an asymmetric information relative to lead risk.

## A. Hedonic Valuation of Lead Risk Phase

My first empirical estimator forms a covariate approach to account for the implicit value of lead risk. The inclusion of explanatory variables could determine an unbiased estimate for my variable of interest. A linear hedonic functional form is chosen to estimate the hedonic valuation of lead exposure risk. The linear function form, although susceptible to omitted variable bias, will produce low mean percentage errors, Cropper *et al.* (1988) and Kuminoff *et al.* (2010).

$$P_i = \beta_0 + \beta_E E_i + \beta_H H_i + \beta_N N_i + \beta_Y Y_i + \varepsilon_i \quad (16)$$

Equation 16 shows the relationship between the linear price  $P$  of household  $i$ , and the vectors of structural characteristics  $H$ , and neighborhood and environmental attributes  $N$ .  $E$  represents the proxy of lead-risk exposure to a house.  $Y$  is the household median income based on the associated Census Tract. Variables in the structural vector include the age of the home, square feet of the home, fixed and half bathrooms, story, property acreage, sale's month and year, and garage type. Neighborhood and environmental variables include if the home is located within a historic district, the associated elementary district performance level, and the home's proximity to a water network or park.  $\varepsilon$  assumes the Gauss-Markov conditions of the idiosyncratic errors.

My second empirical specification sketches an instrumental variable (*IV*) procedure on Equation 16. Since this study does not have an actual variable for water quality, the two-stage least squares (*2SLS*) approach, using strong instruments, is ideal to accurately estimate the influence of water quality on a home price. The first stage regress lead exposure risk  $E$  on the instruments of year prohibition dummy  $\Theta_i$  (i.e., if the home was

built before 1998), the age of the house  $A_i$ , ZIP area  $Z_i$ , and the median household income  $Y_i$ . The final instrumental term  $\Phi_i$  is constructed through the interaction of the instrumental variable.

$$E = \gamma_0 + \gamma_1\Theta_i + \gamma_2A_i + \gamma_3Z_i + \gamma_4Y_i + \gamma_5\Phi_i + u_i \quad (17)$$

In many States, such as Kentucky and Illinois, lead poisoning is pointed out through the ZIP areas. Campaigns preventing children from lead poisoning do focus on ZIP areas with high risk of lead. These areas are used in formulating the level of lead risk in communities. Income is also instrumental in determining lead risks. Homes or communities with low incomes may be vulnerable to lead poisoning. Living below the poverty line, families and communities cannot finance or facilitate the replacement of lead materials or prevent lead poisoning in their private water systems. These families might hardly purchase water filters to treat their water supplies. The age of the home may also contribute to a situation of no, low, or high lead exposure risk. Even though the 1986 amendments to the drinking water system prohibited the use of lead substances in public, residential and nonresidential buildings, it was in the year 1996 it became illegal to use lead materials. So, homes built up to 1997 may have a high likelihood of being exposed to lead poisoning. In the final instrumental factor, the interaction term points out the interdependencies among the variables which could substantially contribute to the vulnerability of lead risk in the water system. These instruments justify the exogenous decisions of whether a homeowner will purchase a home with a probable low risk of lead in the water supply, or not.

$$P_i = \beta_0 + \beta_1\hat{E}_i + \beta_2H_i + \beta_3N_i + u_i \quad (18)$$

Building on the covariate strategy in Equation 16, the predicted  $\hat{E}$  in equation 17 is used as a proxy for  $E$  in the second stage of the *IV* approach. My instruments may not be perfect as it may be correlated with price. Even so, I assume that these variables are strongly correlated with the endogenous variable,  $\hat{E}$ . I also assume that the predicted lead risk variable is uncorrelated with the error term  $u_i$ .

Applying the dummies, which were constructed from the relatively low and high-risk lead neighborhoods, my final verification strategy for causality uses a propensity score matching (*PSM*). The *PSM* approach assures that unexpected prediction can be removed from the observations. Homes located in the relatively high-risk area are positioned as the treatment group, while homes located in the relatively low lead exposure areas are joined to the control group. Following Dawid (1979) conditional independence notation,  $T \perp\!\!\!\perp X \mid U$ ,  $T$  is the treatment group and  $X$  and  $U$  respectively depict the observed and unobserved covariates. An elementary hypothesis of the *PSM* states that the assigned treatment group and the observed covariates are conditionally independent given the true propensity score.

$$X \perp\!\!\!\perp T \mid \pi(X) \quad (19)$$

Equation 19, from Rosenbaum and Rubin (1983) theorem, assumes that a matched treatment-control pair is homogeneous in the covariates  $\pi(X)$ . That is, the treatment and control homes in the lead risk zones will be matched based on the same distribution of  $X$ . Matching the true propensity score will result in the observed covariates of structural, neighborhood, and environmental characteristics being asymptotically balanced between treatment and control groups.

## **B. Testing for Asymmetric Information in Water Quality Phase**

Addressing the concern of asymmetric information, I subscribe to empirical advice from Kurlat and Stroebel (2015). These authors test for information asymmetries in the real estate markets. My data is not perfect to conform to the predictions put forth by Kurlat and Stroebel. An ideal dataset would present information on sellers and categorize the sellers by their level of information, more informed versus less-informed. However, I compute and test for asymmetric information through resale information. The resale value is a summation of the structural characteristics, the attractiveness of the neighborhood and environmental attributes, the loading factor of a house to its neighborhood, and idiosyncratic shocks. In conformance with the arguments from Akerlof (1970) and Kurlat and Stroebel (2015), at the time of resale, it is assumed that information about the value of the home is known. Home sellers are likely to acquire better and plentiful information, relative to knowledge on lead risk than potential buyers. For example, assuming that current homeowners and sellers are rational, they use information from their local water utilities and authorities like the EPA to get information on lead risks for their homes or neighborhoods. In the case of an asymmetric information, *ceteris paribus*, homes in relatively low-lead risk water zones might be better than is commonly known or reflected in local housing price transactions. The same applies to the reverse. The reverse is: Homes in high lead risk water neighborhoods are worse off than commonly known or reflected in home sales. Thus, due to hidden-type information, relatively high-lead risk water neighborhoods might be overrated or horizontally valued, compared to homes in the relatively low lead risk water neighborhoods. Problems with water in homes may not

disclose by home sellers. These assumptions facilitated the building of a deterministic model, as formulated in Equation 18, to check for asymmetric information.

$$\bar{A}j = \sum_{i=1}^n (V_1/V_0)^{1/t} - 1 \quad (20)$$

$\bar{A}$  represents the average appreciating rate of resale homes in low lead risk water neighborhoods if  $j = 0$ , and average appreciating rate of homes in high lead risk water neighborhood if  $j = 1$ .  $V_1$  is the resale price offered by the seller and  $V_0$  is the initial or former price.  $t$  represents the number of time homeowners occupied the property or engaged by the sellers. If  $\bar{A}$  for low-risk water area is not statistically different from the high-risk  $\bar{A}$  or not vertically higher, this would suggest an asymmetric information on water quality. Expressed differently, if the high-lead water risk  $\bar{A}$  is higher and statistically different from the averaged low-risk  $\bar{A}$ , this would also imply an asymmetric information. According to Kurlat's predictions, informed buyers in the housing market are able to select better homes at the same prices than uninformed buyers. With these means, informed buyers will be willing to pay for quality structure homes in a better neighborhood. On the contrary, uninformed buyers will be willing to pay more for houses in a relative overrated neighborhood. Notwithstanding, uninformed buyers can buy homes in both underrated and overrated neighborhoods. Again, I expect, on average, homeowners in high lead risk areas may have little information on lead in their water supply compared to low lead risk neighborhoods.

## **VII. Result**

This section provides findings for the lead risk hedonic valuation and gives a report for the possibility of a hidden type information, with respect to water quality in Fayette County,

Kentucky. Initially, in the hedonic valuation phase, I used the unit level of lead risk exposure in the water supply as my variable of interest. The later stochastic and deterministic models used the segmented high-risk (treatment group) and low-risk (control group) zones variables. Results from the hedonic phase are compared to conventional water quality studies. Findings from the test for asymmetric information are linked to Kurlat and Stroebel (2015) to interpret uninformedness in the market.

#### **A. Water Lead-Risk Influence on Residential Housing Price**

Model 1, defined in Equation 16, allows this study to control for factors that might influence house price and my implicit variable of interest, lead risk in water quality. This specification permits us to determine housing values and the implicit water quality, as the lead risk increase or decrease by a unit. The result of the OLS specification is presented in Table 3.3. I used the robust error treatment to correct for functional and misspecification errors. Given the robust treatment, I do not analyze the percent of variation explained by the model. Still, I find an R-squared of 72% in Model 1.

I find an unexpected result for water quality in Model 1, as reported in Table 3.3. Water lead-risk is not statistically significant at the p-value of 0.05. On this account, I reject the hypothesis that good water quality influences the values of residential homes. A background investigation, using a stepwise control technique, show that water quality variable alone, and time fixed effects of months and years, do not have a strong goodness of fit to explain the linear model. Water quality risk alone produced a significant result, but an R-squared of 0.05; the inclusion of sales months produced an R-squared of 0.05, and sales year, 0.06. Additionally, controlling for the structural, neighborhood, and



environmental attributes increase the explanatory power of the model to 72%. Nevertheless, the finding for the lead-risk variable was not statistically significant at 0.1 or 0.05 p-value.

I applied the Two-Stage Least Square (*2SLS*) estimator to examine the robustness of water quality risk. The *2SLS* estimator modeled that the quality of water relative to lead risk is identified by exogenous instruments, including house age, median household income, lead prohibition fixed effects, and ZIP areas. Initial analysis of the instruments showed a positive correlation between house age and water quality exposure level at 0.69, and a negative correlation between median household income and water quality risk level at 0.66. These findings indicate a respective positive and negative associations of water risk with house age and median household income.

The coefficients of the instruments are statistically significant at 5% significance level in the first stage of the *IV* estimator, except for ZIP area 40504. House age was positive and statistically significant from zero. An increase in the age of the house increases the level of lead risk in the water quality. An increase in the median income of household results in a decrease in water quality risk, a negative and significant result. The result from the second stage also produces an unexpected result of water quality risk, see Table 3.4 An increase in water risk level increases property values. This estimate of water quality risk level, valued at \$164, is positive and non-significant at 5% significance level. Besides interpreting the results from the *2SLS* estimator, I perform post-estimation tests to evaluate the uniqueness of the *2SLS* estimator. First, I perform the test of endogeneity, where the null hypothesis argues that the instrumental variables are exogenous. The robust chi-squared and regression p-values were 0.6227, thus failing to reject the null hypothesis. This

indicates that the instruments were exogenous in nature, and the control specification (the *OLS* Model) did not suffer from endogeneity problems; it was not meant to treat water lead risk as an exogenous variable and using the 2SLS was not necessary. Second, I test for the strength of the 1st stage. I hypothesized that the instruments were weak. The partial R-squared was 0.57, rejecting the null hypothesis that the instruments were weak. Finally, I performed an over-identification (over-id) test for the 2SLS model on the null that the set of instruments is valid, and the model is correctly specified. Findings from the over-id test, at a p-value of 0.0000, reject the null. This indicates an overidentification of the 2SLS model.

In the final model application, which aims to evaluate lead risk hedonic price, I measure the consistency of the water lead risk estimate through the PSM model. Looking back on Table 3.2, the simple ANOVA test showed that the covariates of the treatment and control groups are statistically different. Obviously, these differences alarm the challenge of confounding factors between the treatment and control groups. The second check for confounders employed the standard difference test, using the standard deviations of the covariates means. Results from the standard deviation test also validate the possibility of confounders between the treatment and control groups.

At first, when I used the entire dataset of 70,619, I was unable to find a balanced match between the treatment and control groups. I failed on multiple attempts, despite trying techniques such as changing the functional form from linear to quadratic and cubic function. I also failed when I applied a probit and logistic regressions, and matching algorithm like the nearest neighborhood (NN) and Caliper & Caliper and Radius. For a successful matching, I reassessed the data and chose 4,352 observations for the propensity

score. Note that, I used only continuous variables in new data for the *PSM*. Along with the property acreage control, all dichotomous covariates were dropped because these covariates could not balance the groups, or they violated the matching overlapping assumptions. I applied a probit regression on a common support matching algorithm to estimate the Average Treatment on the Treated effect (ATT). I regressed the treated groups on the covariates of age, age-squared, story, fixed and half bathrooms, and the median income for the household at the Census Tract level.

Holding all other variables constant, while controlling for the structural characteristics common to homes in the groups, Table 3.5 shows that there is a probability that residential homes in the high lead water risk neighborhood is devalued by \$11,1010. This result, computed via the ATT model, is statistically significant. The conventional expectation for water quality is satisfied: In this model, I fail to reject the hypothesis of a higher willingness to pay to avoid lead-risk in a neighborhood water quality. The ATT findings indicate an implicit negative value of neighborhoods or homes that are susceptible to high lead-risk. Table 3.6, the balance table, and Figure 3.4, the balance plot, tabularly and graphically represent the balanced matching. Primarily, the balance table ensures and communicates that my covariates for the treatment and controls were not different to promote confounding. Figure 3.4 visually reinforced Table 3.6 to show that my structural covariates were not biased, and I can trust the ATT estimate for the water quality valuation, in term of water lead risk. Approximately 29% of the sub-dataset (i.e., 1,289 observations) was matched, while 71% of the data was untreated by the propensity estimator.

Unlike the OLS and 2SLS models which are positive and not significant, the PSM estimate coheres with conventional findings on water quality. For instance, Leggett and

Bockstael (2000) find a negative value for increased bacteria in water, and Piper (2003) supports the argument that poor water quality leads to higher treatment cost and higher water rates. I join and support the argument of a positive willingness to pay for good water quality. Residents will positively value environmental attributes, including water quality which is free from harm or negative externalities.

### **B. Asymmetric Information in Water Quality**

Given that a residential home seller is not legally responsible to disclose water quality problems of a home or neighborhood during a sale or resale, I expect that asymmetric information for hidden lead risk in water quality might be present. This might be true, especially for homes in the high-risk water neighborhoods. I constructed a deterministic appreciation rate in Equation 20 to test for any sign of asymmetric information. Hence, I compare the average resale appreciation rates between homes in the high-risk and homes in the low-risk water neighborhoods. To achieve this measure, I first extract a subset of 18,984 observations from the data. These observations are the unique first resales that occurred in Fayette County, Kentucky, considering the data period. During the data cleaning process, I dropped all resales that happened less than six months of the previous sales. Note, it is evident in the dataset that resale occurred up to eight times for some homes in the county between 2000 and 2018.

Table 3.7 reports the findings from the deterministic test. The deterministic test compared the average appreciation rates between the treatment and control groups. Validated by the p-value of 0.05 in Table 3.7, I fail to reject the null expectation that, on average, homeowners in high lead risk areas may have little information on lead in their

water supply compared to low lead risk neighborhoods. Table 3.7 reports that homes in the high-risk water neighborhoods have a vertical appreciation rate relative to homes in the low-risk water zones, and these groups are statistically different from zero. The average appreciation rate for a probable high-risk area is about 52% and the resale appreciation rate for homes in the low-risk neighborhood is about 39%. The vertical difference in the appreciation rate is 13%. This finding is consistent with Kurlat and Stroebel's expectations and results. Informed buyers are likely to use their information in an overrated neighborhood, while uninformed buyers are incapable of distinguishing both the bad qualities in both neighborhoods and homes. Hence, the deterministic test suggests the presence of information asymmetries relative to residents who live in a high lead-risk water neighborhood. The results imply that these residents are unable to detect, gain perfect information, or pay attention to the revealed information which would then give a gist of the level of lead risk in their water supplies. Although results from the deterministic model may suggest the presence of asymmetric information, the results herein are potentially biased because important independent and explanatory variables might have been left out when I specified Equation 20. For example, adding the number of years homeowners or sellers occupied residential homes to Equation 20, I could expect the average appreciation rates to shift to the true values.

## **VIII. Conclusion and Implications**

I argue that residential homeowners will pay more for improved water quality, and homeowners in the high lead risk water areas may have little information on their water supply relative to low lead exposure neighborhoods. Nevertheless, during the time of resale, home sellers are likely to obtain better information, relative to knowledge on lead

risk, than potential buyers. I applied the hedonic analysis to empirically measure the effect of lead risk on housing values. The *OLS*, *2SLS*, and *PSM* specifications were employed to validate the robustness of the implicit lead-risk value.

Accounting only for structural attributes, holding all things constant, I find that homeowners in the relatively low-lead risk water communities are implicitly willing to pay \$11,101 to avoid the likelihood of being poisoned by lead. Analyzed in the deterministic model of appreciation rate, I find that the average appreciation rate from the resale of homes in the probable low-risk area (52%) is higher than the average appreciation rate for homes in the low-risk neighborhood (39%) by 13%. This difference suggests, *ceteris paribus*, buyers in the low-risk areas are better informed about lead risk than the high-risk buyers. Acquiring a higher appreciation rate for homes in the high-lead risk neighborhood could also imply that potential buyers are uninformed and incapable of distinguishing the quality of high lead risks in water neighborhoods. Findings from my stochastic and deterministic models may be vulnerable to empirical pitfalls and may violate regression assumptions, including omitted variable bias. Future studies could detect omitted variables in this research and add important variables to the models.

## IX. Tables

**Table 3.1. Summary Statistic of Continuous Variables of Structural Attributes, Median Household Income and Water Lead-Risk Levels.**

Variable	Observation	Mean	Std. Dev.	Min	Max
Real Price (dollars)	70,619	\$219,328	\$148,676	\$16,202	\$5,649,844
House Age (years)	70,619	35	25	1	207
Home Size (square feet)	70,619	1,846	744	416	10,762
Story	70,619	1.4	0.5	1	3
Fixed Bathroom	70,619	2	1	1	10
Half Bathroom (unit)	70,619	0.5	0.5	0	4
Home acreage	70,619	0.2	0.2	0.002	9.8
Median Income	70,619	\$57,559	\$20,915	\$12,288	\$168,103
Lead Risk (unit)	70,619	4	3	1	10

**Table 3.2. Comparative Summary Statistics of Water Lead-Risk Treatment and Control Groups**

Variable	Low Lead Risk Zone (Control Group) 44,519 Homes	High Lead Risk Zone (Treatment Group) 26,100 Homes	T-Statistics (Pr( T  >  t )
	Mean	Mean	p-value
Real Price (dollars)	246111	173643	0.0000***
Lead Risk (unit)	2	7	0.0000***
House Age (years)	26	52	0.0000***
Home Square Feet (linear feet)	2010	1566	0.0000***
Story (unit)	1.5	1.3	0.0000***
Fixed Bathroom (unit)	2	2	0.0000***
Half Bathroom (unit)	0.6	0.3	0.0000***
Property acreage (acres)	0.23	0.20	0.0000***
Median Income (dollars)	65722	43637	0.0000***

Note: Significant at t statistics: \* p<0.05, \*\* p<0.01, and \*\*\* p<0.001.



**Table 3.3. Estimates of Hedonic Model (OLS Estimator): Lead Risk in Water Quality**

Dependent variable real price adjusted to year 2016 (mean: \$219,328, Std. Dev: \$148,676)				
Variable	Estimate	Robust Std. Error	t-stat	p-value
Water Quality (n=10 levels, $\mu = 4$ )	.204	.230	0.89	0.373
House age ( $\mu = 35$ )	-.237***	.045	-5.26	0.0000
Median Income ( $\mu = \$57,559$ )	.32***	.03	10.33	0.0000
Time fixed effects	Yes			
House characteristics controls	Yes			
Neighborhood fixed effects	Yes			
School fixed effect	Yes			
Observation	70,619			
R <sup>2</sup>	0.72			

Note: Significant at t statistics: \*  $p < 0.05$ , \*\*  $p < 0.01$ , and \*\*\*  $p < 0.001$ . Table 3.3 is a linear specification. The dependent variable, the real price is divided by 1000.

**Table 3.4. Estimates of Hedonic Model (2SLS Estimator): Lead Risk in Water Quality**

Dependent variable real price adjusted to year 2016 (mean: \$219,328, Std. Dev: \$148,676)				
Variable	Estimate	Robust Std. Error	t-stat	p-value
Water Quality (n=10 levels, $\mu = 4$ )	.164	.234	.70	0.483
Time fixed effects	Yes			
House characteristics controls	Yes			
Neighborhood fixed effects	Yes			
School fixed effect	Yes			
Observation	70,619			
R <sup>2</sup>	0.70			

Note: Significant at t statistics: \* p<0.05, \*\* p<0.01, and \*\*\* p<0.001. Table 3.4 is a linear specification. The dependent variable, the real price is divided by 1000.

**Table 3.5. Propensity Score Matching Results for Treated Groups (High-Risk Areas)**

	Treated	Controls	Difference	S.E.	T-stat
Average Treatment on Treated	182.820	193.921	-11.101	5.286	-2.10
Observation	1,289				
Pseudo R <sup>2</sup>	0.32				

Note: Significant at t statistics: \* p<0.05, \*\* p<0.01, and \*\*\* p<0.001. Table 3.5 is a linear specification. The dependent variable, the real price is divided by 1000.

**Table 3.6. Balance Table for the Covariate Matching**

Variable	Treated	Controls	Difference	Bias Reduction	P-value
Age	53	53	-0.28	97.8%	0.460
Square Feet	1744	1746	2.7	97.7%	0.436
Story	1.2	1.2	-0.001	92.0%	0.574
Fixed Bath	2	2	0.0172	99%	0.917
Half Bath	.4	.4	-0.002	98.4%	0.937
Median Household Income	41.72	40.97	-0.749	95.9%	0.074

Note: Significant at t statistics: \* p<0.05, \*\* p<0.01, and \*\*\* p<0.001.

**Table 3.7. Testing for Asymmetric Information via the Average Appreciation Rates between High and Low Water Lead-Risk Communities.**

Dependent variable Log of real price adjusted to year 2016 (mean: 40.86%, Std. Dev: 75%)

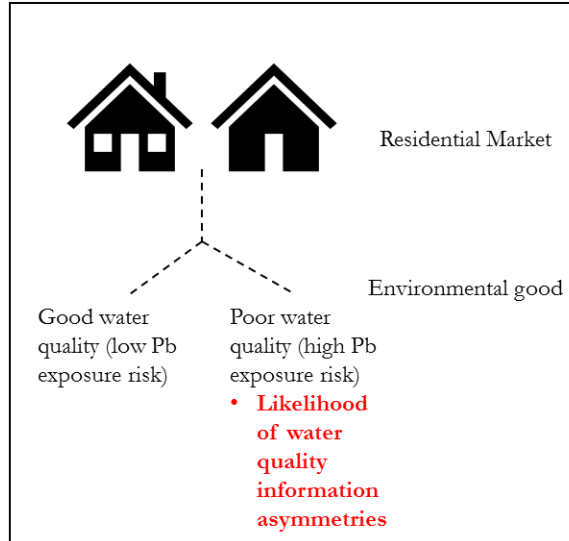
Water-Quality Neighborhood	Sample (Obs.)	Mean Appreciation	Std. Dev.	[Confidence Interval at 95%]	T-stat (P-value)
High-risk Pb Exposure (Level 6 – 10)	3,897	52.47	49.65	49.65 – 55.29	0.0000
Low-risk Pb Exposure (Level 1 – 5)	4,558	38.97	37.09	37.09 – 40.85	
Difference		13.50			

Note: Significant at t statistics: \*  $p < 0.05$ , \*\*  $p < 0.01$ , and \*\*\*  $p < 0.001$ .

## X. Figures

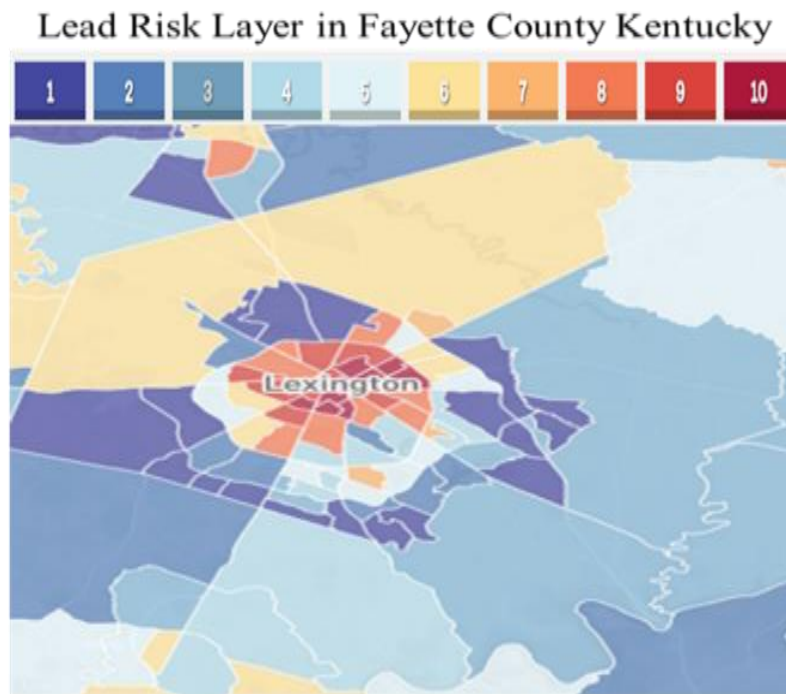
**Figure 3.1. Depicting the Assumption of Water Quality Information Asymmetries**

Depicting the assumption of water quality information asymmetries



**Figure 3.1:** Visually illustrating homes that may be prone to concealed lead risk information in the residential market.

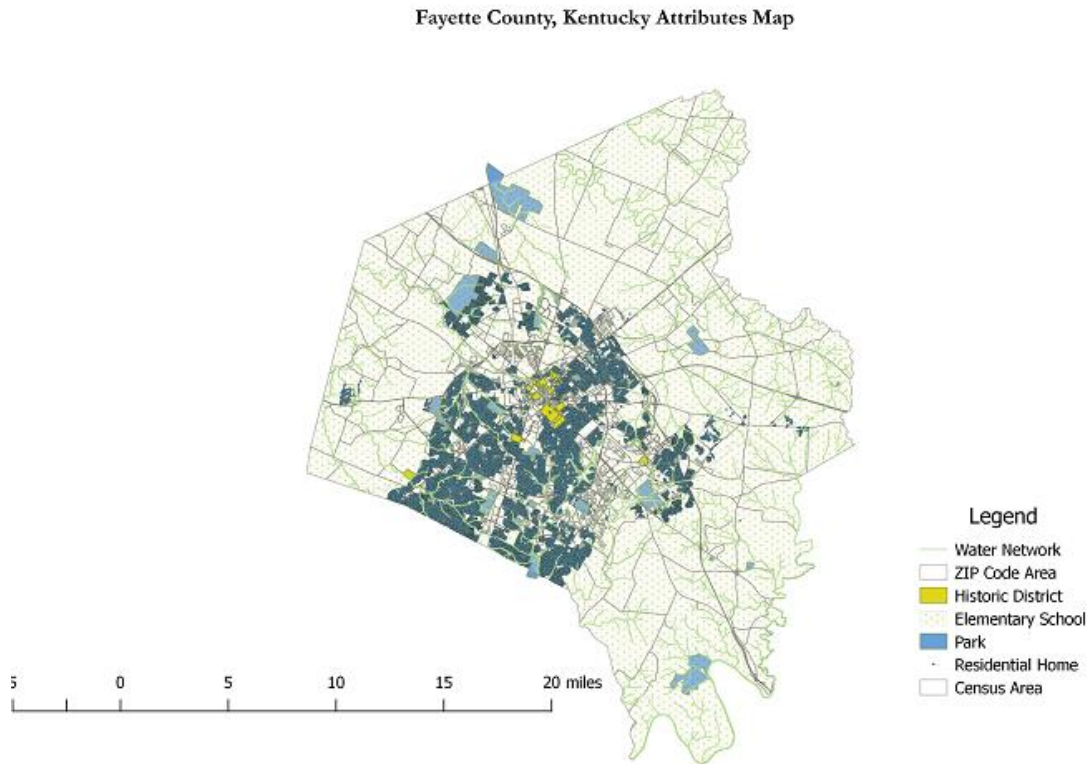
**Figure 3.2. Lead Risk Layers in Fayette County, Kentucky**



Source: Vox

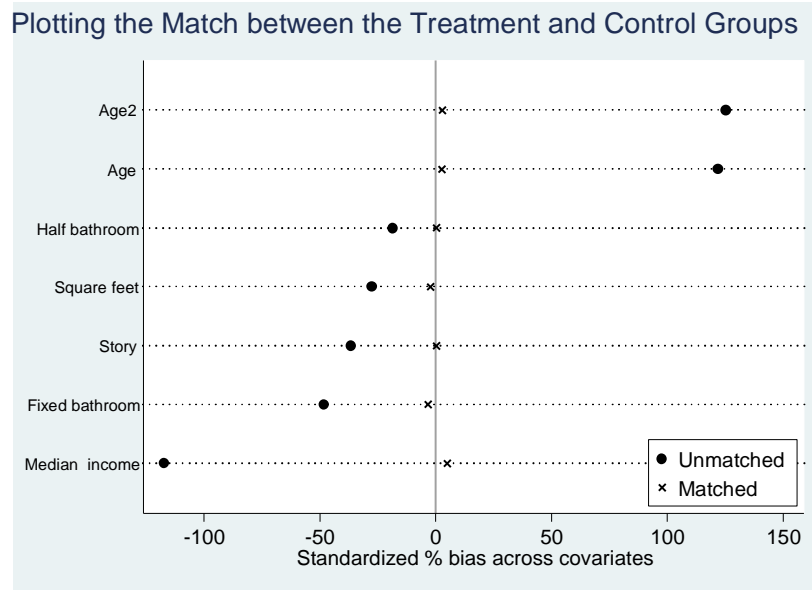
**Figure 3.2:** A snapshot of lead risk map zoomed to Fayette, Kentucky. The map is accredited to Rad Cunningham, Sarah Frostenson, and Vox media. Risk increases in ascending order on the scale of 1 to 10.

**Figure 3.3. Fayette County, Kentucky Attributes Map**



**Figure 3.3:** A cluster of residential home transactions in Fayette County over the period 2000 to 2016. Figure 3.3 graphically illustrates the physical neighborhood characteristics that might influence the price of residential homes.

**Figure 3.4. Plotting the Matching between the Treatment and Control Groups  
(Water Lead-Risk)**



**Figure 3.4:** The reference line portrays a region of no or less biasness at the critical value of 0.05. Note: The  $p > \chi^2$  for the Propensity Score Matching in Table 3.6 has a value of 0.637. This result also portrays and validates a balance between the treatment and control groups.



## **CHAPTER FOUR: CONCLUSION**

Environmental debates sprout from climate change to air pollution. This thesis is a discourse on some of the common environmental issues confronted in the United States of America. In this regard, I focused on the valuations of green spaces (namely, parks and historic districts) and water pollution (in terms of lead contamination in the water supply).

The two essays in this thesis, on green space and water lead-risk, are connected by the concept of the hedonic analysis. Throughout the essays, I use similar variables, including structural, neighborhood, and environmental attributes, to implicitly measure parks, historic districts, and lead risk levels in the water supply. The dataset, provided by Fayette County, Kentucky's Property Valuation Administrator, and the context of Fayette County, Kentucky set the empirical stage to value the environmental issues of interests. The first essay, presented in Chapter 2, showed how parks and historic districts play a key role in the green space campaigns. These attributes are valued for their use-values. Parks are used for health and recreation, hiking, picnicking, and serve as a cherished community and diversified space. Besides preserving historic and cultural properties, historic districts conserve the environment and support energy efficient policies. Despite the positive environmental attributes that stream from parks and historically designated areas, disapprovals or intruding concerns are raised to disclose the under-utilization and underperformances of parks, and the gentrification and high costs that may be associated with historic districts. Given these arguments on the positive and negative attributes of parks and historic districts, I questioned the influence of parks and historic districts on homeowners in order to disentangle their use-values. One should care about these use-

values because parks and historic districts have the propensity to influence property values, private investments, and budgetary financing.

So, in Chapter 2, I find that the willingness to pay for parks is negative, indicating that parks host features which negatively affects their use-value. In the case where I compare properties that have direct access to a park versus properties that lie across the street and interacting parks with the featured amenities, I find a positive hedonic price for parks. Hence, suggesting that parks have positive use values. Positive use-value in parks may be linked to features like the type of park and recreational trails. On the other hand, negative use-values may be linked to features like athletic fields which back noise or light pollution. Given the mixed results, especially the negative valuation, I do not advocate for the elimination of parks. Instead, I argue that parks and park amenities can be managed efficiently to give the expected level of externalities and performances in today's changing environment. All findings show a positive influence of local historic district on the residential markets, implying that positive environmental and economic benefits are associated with local historic districts. Due to the findings that local historic districts have an appreciated sales advantage over their immediate neighborhoods, I equate the result to a spillover effect. Still, I did not carry out an adequate analysis to imply a gentrification phenomenon.

The essay on lead-risk that may exist in the water supply is unearthed in Chapter 3. The Flint, Michigan water crisis reverberated the lead contamination concerns in the United States. Most States face serious lead risks, as EPA disclosed that only nine States report safe levels of lead in their water supply. Identification of lead contamination, trusting the reporting systems, and financing the replacement of lead infrastructures are significant

problems in this area of water pollution. Prioritizing these problems, I focused on the discussion of identifying lead-risk in the residential water supply. Identifying the risk lead pollution in the water supply can be an unquestionable or a borderline case. Therefore, the essay presented in Chapter 3 asks two research questions: First, what is the willingness to pay to avoid lead exposure risk in a water supply system? Second, does information asymmetries among homeowners in the residential market occur relative to their water supplies? I evaluate the first question using a hedonic analysis. I assume that asymmetric information is present for high lead-risk water areas because full disclosure of potential lead risk in the water supply is not legitimately required during the sales of residential properties. The second question is examined by a deterministic model, using an average appreciation rate. Above all, potential lead risk in a water supply is important to discuss due to the connected health and financing implications. For example, 10% to 20% of lead intake in children are caused by water consumption, Rabin (2008).

In Chapter 3, I do not find a statistical result to indicate that homeowners may be willing to pay for homes to avoid water lead-risk. Holding all things constant, and considering only housing characteristics and median household income, I find that homeowners in the relatively low-lead risk water communities might implicitly value water more to avoid the likelihood of being poisoned by lead. I could not incorporate other variables because overlapping assumptions were violated. The cost of excluding controls cause bias in this average treatment result. When I compared the average appreciation rates of resale homes in the probable low and high-water risk areas, I find a higher average appreciation rate for homes in the high-risk neighborhoods. This finding might imply that

residents in the high-lead risk neighborhoods are uninformed and incapable of distinguishing the quality of high lead risks in the water.

The discussions and conclusions inscribed in Chapter 2 and 3 recommend practical implications given the respective findings. Considering parks, I recommend that parks' authorities intentionally use surveys to detect and mitigate the negative use-values and undesirable facilities. In terms of the historic districts, I call for the appropriate authorities covering historic districts to adopt communications and interventions against gentrification and to promote actions for integration. In the vein of lead risk in the water supply, I recommend that local authorities should structure a communication system to identify and disseminate the level of lead risk in water supplies. Also, these authorities should try to make the full-disclosure of water problem a legitimate requirement, in conjunction with the lead-paint full disclosure.

Finally, I recognize the need for future study or post-thesis research to address these environmental issues, namely parks, historic districts, and water lead-risk. A future research needs to conduct a contingency valuation directed at the public, as well as to private homeowners who live in close proximity to parks, in order to capture the negative use-values of park amenities. This step would advise and facilitate financing, technical, and engineering solutions to address issues in parks. In Addition, I call for a study to develop a model to specifically investigate the gentrification phenomena which might be associated with historic districts. Most studies have found significant results in the local historic district. However, these studies are weak in explicitly modeling gentrification issues. Lastly, a future research needs to construct a data to account for buyers and sellers

informedness in the residential market through a stochastic approach in order to investigate asymmetric information relative to lead risk in water supplies.

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