Brownfield Financing in the United States: From Social Benefit-Cost Perspective

by

Rongtao Xu

B.S. in Environmental Science, Nanjing University, 2000

Submitted to the Department of Urban Studies and Planning
In partial fulfillment of the requirements for the degrees of

Master in City Planning
and Master of Science in Real Estate Development
at the
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
June 2006

Signature of Author..
Rongtao Xu
Department of Urban Studies and Planning
May 25, 2006

Certified by..
Professor Karen R. Polenske
Professor of Regional Political Economy and Planning
Thesis Supervisor

Accepted by..
Professor Langley Keyes
Ford Professor
Chair, MCP Committee, Department of Urban Studies and Planning

Accepted by..
Professor David Geltner
George Macomber Professor and Professor of Real Estate Finance
Director, Center for Real Estate

Brownfield Financing in the United States: From Social Benefit-Cost Perspective

by

Rongtao Xu

Submitted to the Department of Urban Studies and Planning
In Partial Fulfillment of the Requirements for the Degree of
Master in City Planning
at the Massachusetts Institute of Technology

Abstract

Since 1995, the government has launched brownfield financing programs to promote brownfield cleanup and redevelopment in the United States. These programs have lowered financial barriers for brownfield developers and returned vibrant properties to communities.

In this study, I focus on examining the efficiency of these incentives from the social perspective and proposing optimal funding decision rules. I hypothesize that brownfield funds are not allocated optimally in some cases. First, I investigate the current brownfield financing programs at federal, state, and local levels. Second, based on externality and welfare economics theories, I propose an optimal funding-decision flow chart. Third, by testing my hypothesis on three brownfield cases in Massachusetts, I perform social benefit-cost analyses and determine whether brownfield funds were justified by their social returns. Finally, I discuss the major findings from these case studies and point out ways to improve current brownfield financial and non-financial policies.

Based on theoretical analyses, I propose that the government should not sponsor projects with positive private net present values, but rather focus on projects that have positive net present social values and not feasible without subsidies. In the real world, it is difficult to measure the social benefits of a brownfield redevelopment accurately, especially before a development project is completed. Hedonic models show that only one of three cases exhibit significant positive enhancement on housing values after redevelopment. Only development of a simple rule-of-thumb benefit assessment toll would make an optimal brownfield funding decision possible.

Thesis Supervisor: Karen R. Polenske, Professor of Regional Political Economy and Planning, Department of Urban Studies and Planning
Thesis Reader: David Geltner, Professor and Director, Center for Real Estate

ACKNOWLEDGEMENTS

First and foremost, I would like to express my gratitude to my advisor and thesis supervisor, Professor Karen R. Polenske, who introduced me to Master of City Planning Program and to my thesis topic, and who has given continuous advice and support throughout my two years' studies at MIT.

I thank Professor David Geltner for introducing me to a lot of literature, which helped me understand the forefront issues in this field. His wonderful real estate finance courses enlighten me to design the research.

I offer special thanks to Dr. Henry O. Pollakowski and Mr. Andrew Jakabovics, who provided me valuable advice on building hedonic models and helped me locate real estate transaction data. Both of them are extremely busy, but spend a great amount of time and efforts, even holidays, in offering help.

My research would not have been possible without the willingness of Warren Group to share their valuable housing transaction data.

I am grateful to Ms. Lisa Sweeney and Mr. Daniel Sheehan, GIS specialists at Rotch Library, who provided me with GIS help. They were very patient and willing to teach me step by step.

I also appreciate the help I received from Dr. James Hamilton, who helped me connect with local contacts in brownfield redevelopment and gave me valuable comments.

I am indebted for advice and provision of data to Dr. Kris F. Wernstedt at RFF, Ms. Carol Tucker at EPA region One, and Mr. Mark Hawke at Community Development and Planning Department, City of Gardner.

My research was supported during the past two years by a tuition grant from the Department of Urban Studies and Planning and stipend grants from accounts 3903800 and 3655700 (MIT Multiregional Planning Research Fund). I thank MIT for making this research possible.

I appreciate that Sandy Wellford and Maria Vieira gave me encouragement as well as administrative help. I thank Dr. Jinbao Tong and Mr. Hongliang Zhang for their valuable comments.

Last, but not least, I am grateful to my parents and my wife. Their long-term support and encouragement have kept me moving forward in my research and studies at MIT.

CONTENTS

ABSTRACT 2
ACKNOWLEDGEMENTS 3
CONTENTS 4
FIGURES 7
TABLES 8

CHAPTER 1 INTRODUCTION AND BACKGROUND 9

1.1 METHODOLOGIES 9
1.2 DATA AND SOFTWARE 11
1.3 OVERVIEW OF CHAPTERS 11

CHAPTER 2 BROWNFIELD FINANCING IN THE UNITED STATES 13

2.1 BACKGROUND 13
2.1.1 What is a Brownfield? 14
2.1.2 Brief History of Regulations on Brownfields and Superfund Sites 15
2.1.3 Major Obstacles for Brownfield Redevelopment 16
2.1.4 Stakeholders and Their Perspectives in Brownfield Redevelopment 17
2.2 SPECIAL COSTS FOR BROWNFIELD REDEVELOPMENT 21
2.2.1 Direct Costs 21
2.2.2 Indirect Costs 23
2.3 FEDERAL, STATE, AND LOCAL BROWNFIELD FINANCING PROGRAMS 24
2.3.1 Federal Programs 25
2.3.2 State and Local Programs 28
2.4 PROS AND CONS OF THE CURRENT U.S. BROWNFIELD FINANCING PROGRAMS 29
2.4.1 Pros of Current Brownfield Financing Programs 29
2.4.2 Cons of Current Brownfield Financing Programs 30

CHAPTER 3 OPTIMAL BROWNFIELD INCENTIVES **32**

3.1 THEORETICAL ANALYSES – OPTIMAL GOVERNMENT INTERVENTION 32

3.1.1 Externality and Market Failure *32*

3.1.2 An Optimal Funding Allocation Mechanism *36*

3.2 RESEARCH HYPOTHESIS 38

3.3 METHODOLOGIES 38

3.4 MEASURING SOCIAL INVESTMENT COSTS AND BENEFITS OF BROWNFIELD PROJECTS .. 39

3.4.1 Rationale of Selecting Benefits and Costs *40*

3.4.2 Measuring Public Costs of Brownfield Redevelopment *40*

3.4.3 Measuring Public Benefits of Brownfield Redevelopment *41*

3.5 HEDONIC MODEL 44

3.5.1 The Principles of Using Hedonic Model *44*

3.5.2 Data Sources *45*

3.5.3 Model Specification *46*

3.5.4 The Process of Model Building *47*

3.6 CONCLUSION 50

CHAPTER 4 CASE STUDIES IN MASSACHUSETTS **51**

4.1. CASE ONE: BROCKTON, MA 51

4.1.1 Site Description *52*

4.1.2 Data Set *54*

4.1.3 Data Analyses *55*

4.1.4 Review of Regression Results *57*

4.1.5 Comparison Between Before and After Remediation Effects *59*

4.1.6 Discounted Cash-Flow Analysis for Brownfield Investment *62*

4.1.7 Conclusion *63*

4.2 CASE TWO: GARDNER, MA 64

4.2.1 Site Description *64*

4.2.2 Data Set *66*

4.2.3 Data Analyses *67*

4.2.4 Review of Regression Results *68*

4.2.5 Comparison between Before and After Remediation Effects *70*
4.2.6 Conclusion *73*
4.3 CASE 3: LYNN, MA 75
4.3.1 Site Description *75*
4.3.2 Data Set *77*
4.3.3 Data Analyses *79*
4.3.4 Review of Regression Results *79*
4.3.5 Comparison Between Before and After Remediation Effects *81*
4.3.6 Conclusion *86*
4.4. MAJOR FINDINGS FROM CASE STUDIES 86
4.5 CAUTIONS WHEN INTERPRETING RESULTS 87

CHAPTER 5 CONCLUSION 91

5.1 THE MAJOR FINDINGS OF THIS STUDY 91
5.1.1 The Ideal Situation for an Optimal Brownfield Funding Decision *92*
5.1.2 Measurement of Public Benefits and Costs *92*
5.1.3 Background Noise for the Impacts of Brownfields and Brownfield Redevelopment *93*
5.2 ISSUES IN THE METHODOLOGIES AND FUTURE IMPROVEMENTS 94
5.2.1 The Limitation of Hedonic Model in Evaluating Social Benefits *94*
5.2.2 Difficulty in Tracking Public Funds and Social Costs *95*
5.2.3 Difficulty in Measuring the Full Public Benefits *96*
5.3 POLICY RECOMMENDATION 96
5.3.1 Optimize Brownfield Funding *96*
5.3.2 Proliferate Non-financial Incentives *99*

REFERENCES 101

FIGURES

Figure 3.1 Greenfield Development……………………..……………….........................35
Figure 3.2 Brownfield Redevelopment…………………..……………........................36
Figure 3.3 Proposed Optimal Brownfield Funding Decision-Flow Chart……………….37
Figure 4-1 ArcGIS Map of Brockton, One-Mile Radius of the Brownfield Site…………53
Figure 4-2 Photograph and Air Photograph of the Redeveloped Site in Brockton……54
Figure 4-3 Price-Distance Slope Before and After Remediation……………………..…...62
Figure 4-4 ArcGIS Map of Gardner, Half-Mile Radius of the Brownfield Site………….65
Figure 4-5 Photograph and Air Photograph of the Redeveloped Site in Gardner, MA...66
Figure 4-6 ArcGIS Map of Lynn, Half-Mile Radius of the Brownfield Site………………76
Figure 4-7 Photograph and Air Photograph of the Empire Laundry Site in Lynn, MA…………………………………………………………………………………...77

TABLES

Table 2-1 Summary of Brownfield Financing Programs………………………………… 25

Table 4-1 Highlights of Former Shoe Factory Site in Brockton………………………….51

Table 4-2 Descriptive Statistics for the Brownfield in Brockton………………...……..55

Table 4-3 Regression Results for the Brownfield in Brockton………………...………58

Table 4-4 Regression Results for the Brownfield in Brockton, 1994 to 2001………….60

Table 4-5 Regression Results for the Brownfield in Brockton, 2002 to 2006…………..61

Table 4-6 Discounted Cash Flow for Brockton Brownfield………………...………….63

Table 4-7 Highlights of the 30 Wickman Drirve Site in Gardner, MA……………………64

Table 4-8 Descriptive Statistics for the Brownfield in Gardner, MA………………… 67

Table 4-9 Regression Results for the Brownfield in Gardner, MA…………………...….69

Table 4-10 Regression Results for the Brownfield in Gardner, MA, 1996 to 2001…….71

Table 4-11 Regression Results for the Brownfield in Gardner, MA, 2002 to 2006…….72

Table 4-12 Regression Results for the Brownfield in Gardner, MA with Distance and Structural Dummies………………...………………………...……………74

Table 4-13 Highlights of Empire Laundry Site in Lynn, MA………………...…………75

Table 4-14 Descriptive Statistics for the Brownfield in Lynn, MA…………………..…..78

Table 4-15 Regression Results for the Brownfield in Lynn, MA………………...…….80

Table 4-16 Regression Results for the Brownfield in Lynn, MA, 1994 to 2001 (Pre-Remediation) ………………...…………………………………...…..82

Table 4-17 Regression Results for the Brownfield in Lynn, MA, 2002 to 2006 (Post Remediation) ………………...………………………………………83

Table 4-18 Regression Results for the Brownfield in Lynn, MA with Distance and Structural Dummies ………………...……………………….……………85

Chapter 1

Introduction and Background

The deindustrialization in the United States led to the shift of manufacturing industries away first to the South and then to Asia, which left a great amount of vacant and polluted land (brownfield), especially in the Northeast of the United States. The legacies from deindustrialization have become a stigma for communities. It is not just an eyesore, but reduces tax revenues, impacts neighbor properties values, and poses a threat to human health. Since 1995, the government has mitigated the liabilities and provided financial assistances for brownfield redevelopment. These programs have promoted brownfield cleanup and redevelopment and boosted economic development and job growth.

In this study, I focus on financial incentives for brownfield remediation and redevelopment in the United States. From the social perspective, I examine the efficiency of brownfield funding allocation mechanisms and explore how to improve the system so as to maximize the social benefits. My hypothesis is that brownfield funds may not be allocated optimally in some cases.

1.1 Methodologies

I use case studies, benefit-cost analysis, and hedonic models to obtain my research findings.

Case studies

To support my hypothesis, I select three brownfield redevelopment cases in Massachusetts from EPA brownfield success stories to analyze the public benefits and costs. The EPA Region One brownfield website provides background information of the site and redevelopment (Source: http://www.epa.gov/NE/brownfields). I conduct the interviews with local planner to obtain further information.

Benefit-Cost Analysis

I examine public benefits and costs of the three brownfield cases and calculate the net present social values (NPSV). The public costs are the amount of public funds invested in a brownfield redevelopment project. I ignore indirect costs of a redevelopment, such as infrastructure, traffic, noise, and new pollution problems. Due to resource limitations, I only consider the local residents' benefits from brownfield redevelopment and omit the benefits for local business and the general public. The core part of this study is to measure public benefits, since the costs are straightforward.

Hedonic Model

I employ hedonic models to measure indirectly local residents' benefits from brownfield cleanup and redevelopment. The price-distance slope reflects residents' willingness to pay for living farther away from the brownfield before remediation. The slope decrease after remediation should represent the brownfield redevelopment's impact on housing price. By aggregating the price change for each house in the impact region, I derive the local residents' benefits from brownfield remediation and redevelopment.

1.2 Data and Software

Housing transaction data are provided by the Warren Group (2006). I obtain background information of the three brownfield redevelopment cases from the EPA Region One website and local planning agencies. I use ArcGIS and U.S. Streetmap to perform the GIS analyses and use SPSS as the statistical analysis tool.

1.3 Overview of Chapters

The framework of the remaining chapters is as follows.

In Chapter 2, I first elaborate the background for brownfield regulations, the stakeholders in brownfield redevelopment, and the government's roles in aligning the interests of all the parties. Then, I detail the special costs for brownfield developers and review current financing programs. Finally, I analyze the pros and cons of current incentives.

In Chapter 3, I first provide a theoretical framework for the analysis, including externalities and market efficiency. Based on the theoretical analysis, I propose an optimal brownfield financing-decision flow chart. Finally, I introduce my hypothesis and research methodologies, including case studies, benefit-costs analyses and hedonic models.

In Chapter 4, I use single-family housing transaction data to perform hedonic analyses to obtain local residents' benefits from brownfield redevelopment. Based on public costs and benefits, I calculate the return for the public from brownfield redevelopment. In conclusion, I summarize the findings from the case studies and provide a caution when interpreting the results.

In Chapter 5, I first reiterate the major findings of this study, then, I point out the issues concerning the methodologies I used, and, finally, I propose policy recommendations.

Chapter 2

Brownfield Financing in the United States

The financial obstacle for brownfield redevelopment is the extra costs related to brownfields, such as site assessment and remediation that they incur. These costs make brownfield projects difficult to compete with greenfield development in comparable locations. Since 1995, many federal and local programs have been established to provide financial assistance to brownfield developers to promote brownfield redevelopment. In this chapter, I first brief the background of brownfield financing programs and their roles in aligning all the parties' interests in brownfield redevelopment. Then, I point out the special costs for brownfield redevelopment and review current brownfield financing programs in the United States, both at the federal and local levels. I conclude this chapter by examining pros and cons of brownfield financing programs.

2.1 Background

This section describes the history of brownfield regulations and the goals of four stakeholders in brownfield redevelopment.

2.1.1 What is a Brownfield?

Brownfield is a property with the pollution imposed by previous industrial activities, but the level of pollution is less than Superfund sites, which are the most polluted sites listed on the National Priority List (NPL). Based on HRS (hazard ranking score), those polluted sites with HRS over 28.5 will pose immediate or substantial threat to human health and will be categorized in NPL (Wang et al. 1998). EPA will use Superfund programs to finance or perform the clean-up activities and sue the responsible parties to recover clean-up costs. Other polluted sites with HRS lower than 28.5 will be subject to state legislatures.

The official definition of brownfield by the U.S. EPA is “real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant” (The Small Business Liability Relief and Brownfields Revitalization Act 2002). The National Roundtable on the Environment and the Economy (NRTEE 2005) defines brownfield as “an abandoned, vacant, derelict or underutilized commercial or industrial property where past actions have resulted in actual or perceived contamination and where there is an active potential for redevelopment”. People often use “Brownfield” as contaminated land or land with existing structures, by contrast to "Greenfield” (undeveloped land). There are other interchangeable or similar Items, such as “Improvement Areas”, “Special Sites”, “Smart Growth Opportunities”, and signature sites, impacted sites (Newfoundland) (aboutREMEDIATION 2005). In developing countries, such as China, there is no academically recognized term for brownfield.

2.1.2 Brief History of Regulations on Brownfields and Superfund Sites

Before 1976, the disposal of industrial and hazardous wastes was unregulated in the United States (Simons 1998). RCRA (the Resource Conservation and Recovery Act) was passed in 1976, followed by the Comprehensive Environmental Response Compensation and Liability Act—CERCLA, known as Superfund Law in 1980, to hold polluters responsible for cleaning up the pollution they produced. While RCRA imposes stringent regulations on the generation, transport, treatment, and disposal of hazardous wastes, CERCLA elaborates "expansive liability on a diverse number of parties contributing to the hazardous substances", so-called "strict, retroactive, joint, and severable liability" (Simons 1998). The Superfund law has been a major obstacle for brownfield redevelopment, because it imposes liabilities to any party in the chain of title, whether or not they contributed to the pollution or not. Furthermore, RCRA and CERCLA allow for federal, state, and local governments and private parties to sue potential responsible parties for the clean-up or reimbursement of cleanup costs (Simons 1998). This makes it impossible for developers to settle liability waivers from all potential parties. The Superfund alone costs about $1.5 billion annually, while it only accounts for a small percentage of the approximately 450,000 brownfields in the United States (EPA 2002).

Realizing the obstacles imposed on brownfield redevelopment and neighborhood revitalization, the inflexible Superfund law since 1995 has begun to be replaced by state voluntary cleanup programs (VCPs) for non-NPL sites (brownfields). In 1995, EPA removed 20,000 sites from CERCLA and promoted revitalization of these less polluted properties (Lange and McNeil 2004). VCPs are enacted to remove the impediments in brownfield redevelopment, including legal liability mitigation, technical assistance, and economic incentives. VCPs employ risk-based cleanup standards, which make clear for developers the remediation level and potential cleanup costs. States will issue a closure letter to notify developers that the remediation requirements are met. There are two types of state closure letters, i.e. NFA (no further action) and CNTS (covenant not to sue) (McCarthy, 2001). An NFA is issued by state agencies or certified private consultants to certify that no further action is required on the site "regarding the remedial action just completed" (Simons 1998). CNTS ensures all the state agencies not to sue in the future, except for certain conditions (reopeners). A Memorandum of Understanding (MOU) with EPA further binds EPA not to sue the owner in the future. VCPs also offer lenders and new owners exemptions from liabilities (McCarthy, 2001). In 2002, President George W. Bush signed into law "The Small Business Liability Relief and Brownfields Revitalization Act," which grants federal liabilities relief and expands economic assistance to brownfield developers.

2.1.3 Major Obstacles for Brownfield Redevelopment

Liabilities and the extra costs associated with cleanup are the major obstacles for brownfield redevelopment. Developers of brownfields are confronted with higher development costs than developers of conventional development projects. The obstacles are especially larger for projects in non-prime locations and distressed areas, where brownfield cleanup and compliance costs make the financial situations even worse. In prime locations, remediation costs may be absorbed by the revenues from the strong market. However, the liabilities create great uncertainties for developers, lenders, and equity investors even in these locations. It is very difficult to predict the cleanup and compliance costs beforehand. The Federal government can step in and hold developers responsible for new pollution problems, and individuals can sue developers and request them to compensate for their health problems. Before 1996, even lenders foreclose brownfield properties could enter the liability chain. The lender and fiduciary liabilities were waived via the passage of Asset Conservation, Lender Liability, and Deposit Insurance Protection Act of 1996 (McCarthy 2001). With high uncertainties and perceived risks, the costs of capital for brownfield projects are much higher, which result in the failure of brownfield project to pass feasibility studies by developers and investors. Besides the liabilities and costs, the prolonged timing makes developers stay away from brownfields. The timing is critical for the real estate industry. Developers would like to move ahead with projects if they sense the market will become favorable. However, the additional entitlement procedures, such as assessing the site and obtaining an NFA, will prolong the delivery period (McCarthy, 2001).

2.1.4 Stakeholders and Their Perspectives in Brownfield Redevelopment

There are multiple stakeholders involved in the process of brownfield redevelopment, including local residents, developers, the city, and the presumed society at large. They may have different objectives and motivations, which sometimes are in conflict. One of the usual cases is that community groups often want to transform a brownfield into open space, while the city intends to focus on generating jobs and revenues through development projects (Greenberg and Lewis 2000).

Developers

Stated in a simple way, the motivation for private developers[1] is to make money from development projects, though in rare cases some private developers may be involved in projects for the pure purpose of public benefits. The basic evaluation principle for developers is that a project must have a reasonable likelihood of making profits. Development has uncertainties and risks, otherwise developers cannot make higher returns than safe investments, such as treasury bonds. Developers take the risks and are rewarded with high returns. Brownfield redevelopment involves more uncertainties than general development projects so that it requires higher returns. It also depends on the expertise of individual developers. Some developers have a better understanding and control of environmental and legal issues in brownfield redevelopment. So they can reduce the costs of capital and have better chances to win the projects.

Developers usually perform feasibility studies before making investment decisions. They first obtain the market information in the delivery period (development completion), such as the forecasted rent and vacancy rate for a certain final use in the same location as the brownfield. Based on the estimation of construction costs and debt financing cost, they derive projected levered internal rate of return (IRR) and net present value (NPV). If the IRR is larger than the threshold (the required return) or NPV is equal to or larger than zero, they will usually start the development project. Compared to conventional development projects, brownfield redevelopers are confronted with some unique issues. On the benefit side, they often can build on existing infrastructure, gain

[1] It is noted that this study only refers to private for-profit developers, sometime using developers interchangeable. I does not consider mission-oriented or non-profits developers, such as Community Development Corporations (CDC).

zoning variances, and receive government subsidies. On the cost/risk side, they are exposed to extra remediation costs, compliance costs, liability concerns, and protracted timing. Developers also consider other non-financial factors, such as the marketability of the property due to a polluted stigma, and the support from community and politicians (Wernstedt et al. 2004). Developers will carefully factor these unique issues into feasibility studies.

Developers do not take public benefits into consideration when they make investment decisions. Although a brownfield redevelopment may bring great benefits to the city, local residents, or the society, without a positive NPV, developers may not get involved. Many scholars and policy makers advocate a public-private partnership, which tries to align the public and private interests (Battle, 2003).

City

The city where a brownfield is located will benefit from brownfield redevelopment. It transforms a vacant land and eyesore into a revenue- and job-generating property. First, the city gains property tax from the redeveloped site. Generally speaking, brownfields do not have active uses and contribute zero property tax. Second, the cleanup and redevelopment creates short-term employment and redeveloped commercial or industrial uses bring long-term jobs. Finally, the redevelopment and final uses create expenditure and other incomes for the city. Most cities prefer to redevelop the brownfield into a commercial or industrial use, which produces the highest tax revenue and job growth. A proposal of redevelopment with final use for public parks is definitely in conflict with the city's interests in obtaining revenues (Greenberg and Lewis 2000).

Local Residents

Local residents usually benefit directly from brownfield cleanup and redevelopment. Removing residual pollutants reduces the health risks. Redevelopment of a vacant site into a vibrant use increases the aesthetic value of the neighborhood, which potentially increases their house prices and reduces crime rates. However, a redevelopment project may create negative impacts on the neighborhood, especially for commercial and industrial uses. These activities may create traffic, noise, and tax-rate increases. In many cases, residents prefer green space and recreational uses to commercial uses, which is in conflict with the city's interests (Greenberg and Lewis 2000).

Society

Although no such interest groups exist in the real world, I presume that the society represents the aggregate benefits of every person in a country. From the social perspective, job creation and tax growth may be no more than the transfer from a place to another. Environmental and health benefits, such as saving of green spaces and reducing cancer-incidence rate, are the major benefits from brownfield redevelopment. Federal financial resources should be used with the goal of maximizing the social benefits.

All in all, developers, local residents, and the society may have different goals for brownfield redevelopment. Developers focus on the private profits from the redevelopment. The city targets job creation and tax revenue growth. Local residents pay attention to the health benefits and neighborhood improvement. In this study, I focus on social perspective to examine the effectiveness of federal brownfield funding programs. The goal from the social perspective is to maximize the social benefits through the incentives. In this study, I only consider financial factors for developers to make decisions on brownfield redevelopment. I acknowledge non-economic factors that impact developers' decisions, such as liability mitigation and the support from the community and local politicians. I assume that the federal government has limited funding sources for brownfield remediation and redevelopment, so it intends to prioritize funding towards the projects with the maximum social return (IRR).

2.2 Special Costs for Brownfield Redevelopment

Compared to greenfield projects, brownfield developers will have to spend extra money on site assessment, remediation, and other types of redevelopment efforts. Some costs can be observed directly, while other (indirect) costs are hidden in the pro-forma. Direct costs are well documented in various literature, but indirect costs are often overlooked by researchers and regulators.

2.2.1 Direct Costs

Site Assessment. Developers need to understand the level of pollution and the cost and time of remediation through site assessment before making the development decision. In Phase One assessment, they review public records, physical surroundings, and other readily available data for the site; if needed, they will perform a detailed site assessment (Phase two assessment), such as environmental engineering investigation, sampling, and chemical analysis of the site (McCarthy 2001). Assessment costs range from $20,000 to $500,000 (or more), depending on lot size, data availability, level of pollution, site history, clean-up requirements, etc. It is difficult to differentiate the assessment cost premium for brownfields, compared to other conventional development projects.

Environmental Remediation. Brownfield analysts categorize remediation costs into one-time, ongoing operation and maintenance of remediation efforts and remedies, coordination and processing of remediation plan, and application and follow-up with regulatory parties (Simon 1998). Remediation costs depend upon the required clean-up levels, which are defined by risk-based cleanup standards. The standards consider site conditions (types of soils and water table) and the site’s end use (Simon 1998). Site conditions determine the travel potentials of pollutants, while end uses decide human health impacts. Generally speaking, residential uses require stringent standards, while industrial uses may have relatively loose cleanup requirements, considering the potential environmental risks.

Environmental Remediation Insurance. During brownfield cleanup and redevelopment, developers may be faced with unforeseeable costs and law suits from other parties. Developers generally purchase environmental remediation insurance to insure against the environmental risks in brownfield redevelopment. There are two forms of environmental insurance available for remediation, cost-cap coverage and pollution legal liability. Cost-cap insurance (stop-loss coverage) makes sure that the remediation cost over a certain level will be covered by insurance companies. Pollution legal liability protects the property owner against liabilities to third parties for off-site injury, property damage, and remediation costs caused by migrating contamination. The typical costs for pollution legal liability coverage for a seven-year term would be 2 percent of project cost. (Simons 1998; McCarthy 2001)

2.2.2 Indirect Costs

Financing Premiums. In addition to specific costs mentioned above, the typical financing costs for brownfield redevelopment may be higher than conventional development projects. According to the Northeast-Midwest Institute's report, "Financing Strategies for Brownfield Cleanup and Redevelopment" (2003), the financing premiums for brownfields are reflected in three ways: (1) Lenders tend to require borrowers to put at least 25 percent of equity to safeguard lenders' positions. The higher equity percentage means higher costs for the projects, because the cost of equity is generally higher than that of debt. (2) Debt and equity investors may require higher returns. The report shows that the brownfield premium for equity is 10 to 20 percent and for debt is around 2 to 3 percent. (3) The underwriting costs for brownfield projects are higher. Lenders may require further analyses on environmental data and the collateral value. (Bartsch and Wells 2003)

Legal Fees. Due to the complicated liability issues involved in brownfield redevelopment, developers generally pay higher legal fees than those for conventional development projects. For example, developers need to pay for filing legal documents to comply with various regulations on brownfields.

Extended Development Period. In order to perform extra environmental/legal due diligence and environmental remediation, developers may spend more time on brownfield redevelopment than other greenfield projects, which makes projects more time-consuming and usually more expensive. First, the prolonged timing means lower returns, even with the same costs and revenues. For example, a real estate development project incurs the cost of $120M in year 1 and gains revenues plus sales of the projects of $150M in year 2. The project-level IRR is 25%. If the cost of $120M is divided into 2 periods, all other things being equal, the project-level IRR would be 16%. Second, the extra time also reflects more equity developers have to put in brownfield projects. Developers would have less time to work on other projects if they spend more time on the legal and environmental process of brownfields. Last, but not least, in the development industry, timing is very important. Developers may lose a project or incur great economic losses if they are late in bringing their product to the market.

2.3 Federal, State, and Local Brownfield Financing Programs

Realizing the difficult economic situation for brownfield redevelopment, many brownfield financing programs have been established in the United States to lower the financial barrier. There are numerous financing tools available at federal, state, and local levels for brownfield redevelopment in different development phases, ranging from site preparation, planning, site assessment, cleanup, to construction (Table 2-1). Different types of financing programs have been designed, such as loans, grants, and insurance. Federal and state agencies provide low-or-no-interest loans for brownfield assessment and cleanup efforts. Grants are available for brownfield assessment and remediation. Cities sometimes provide guarantees for cleanup costs overrun so that developers can secure debts or lower the interest payments. Based on my literature review, most of current financing programs only target the direct costs, i.e., assessment and remediation costs, though some programs are designed to alleviate debt-financing costs.

Table 2-1: Summary of Brownfield Financing Programs

Agency	Program	Uses	Eligible Entities
EPA	Site Assessment Grants	Assessment	State and local government agencies
	Revolving Loan Grant	Remediation	
	Cleanup Grants	Remediation	
HUD	BEDI	Remediation	
EDA	Public Works and Economic Development Programs	Remediation	
Treasury	Tax Incentives	Tax Deduction	Developers
States or Cities	Tax Incremental Financing	Assessment, remediation,planning, site preparation	Developers
	GO Bonds	Site acquisition, remediation, infrastructure	Local governments

Source: Bartsch and Wells, 2003. Financing Strategies for Brownfield Cleanup and Redevelopment. Washington DC: Northeast-Midwest Institute.

2.3.1 Federal Programs

EPA and the Department of Housing and Urban Development's (HUD) are two major funding sources at the federal level. Brownfield developers sometimes can tap other federal funding sources if it conforms to their criteria, with the target issues such as economic development, housing, and job creation.

U.S. Environmental Protection Agency Assessment and Cleanup Programs. Four EPA financing programs have been used to promote brownfield redevelopment since 1995, including assessment grants, revolving loan fund grants, cleanup grants, and job training grants. (1) Site-assessment demonstration pilot programs provide grants of up to $250,000 over two years per site for assessing sites and designing clean-up and redevelopment models. (2) Brownfields cleanup revolving loan fund (BCRLF) programs provide low-or-no-interest loans of up to $1,000,000 over five years for the cleanup. (3) Site cleanup grants, started in FY 2003, can be used to clean up brownfields conducted by cities, development agencies, and nonprofit groups at sites that they own. (4) Job-training pilot programs furnish grants of up to $20,000 over two year for training residents of impacted areas for future employment in environmental field. In 2003, EPA announced $73 million in grants: 117 Assessment Grants, 28 Revolving Loan Fund Grants, 10 Job Training Grants, and 69 Cleanup Grants. EPA funds generally are not directly awarded to individual developers, but rather they are given to local government agencies or NGOs. EPA considers the following factors when making funding decisions: ownership status, size, access, districts, public benefits, cost, and contamination. (Source: http://www.epa.gov/swerosps/bf/pilot.htm)

U.S. Department of Housing and Urban Development's (HUD) Brownfield Economic Development Initiative (BEDI) program. HUD recognizes that brownfields are one of the major obstacles for economic and community development. Section 108 provides financing to local governments for property acquisition, rehabilitation, construction, site improvement, and other development activities. The BEDI program is designed to assist cities in the redevelopment of abandoned and underutilized sites so as to increase the tax base and create jobs. BEDI funds must be used in conjunction with a new Section 108-guranteed loan commitment by providing funds for land write-down, remediation, fund reserves, direct enhancement for Section 108 loans, etc. HUD awarded $25 million grants and loan guarantees to brownfield projects in 2003. (Source: http://www.hud.gov/offices/cpd/economicdevelopment/programs/bedi/index.cfm)

Economic Development Administration Programs (EDA). EDA has allocated 20 percent of its funds, about $35 million a year, on brownfield related activities. EDA's Public Works and Economic Development Programs is the major source of funds for brownfield redevelopment. The funding can be used for infrastructure enhancement, i.e., remediation costs specifically for brownfields. EDA funding is larger ($900,000 on average) and more flexible in terms of purposes than other sources. However, to be eligible for this funding, the communities must meet the target unemployment rates. (Bartsch and Wells, 2003)

U.S. Treasury Brownfield Tax Incentives. Brownfield tax incentives were originally signed into law in August 1997, the Taxpayer Relief Act (Public Law 105-34) to "spur the cleanup and redevelopment of brownfields in distressed urban and rural areas" (EPA 2004). The U.S. Taxpayer Relief Act 2000 prescribes that environmental cleanup costs are fully deductible in the year they are incurred, rather than capitalized. According to the EPA Brownfield website, approximately $300 million of remediation costs in 8,000 brownfields are waived annually, and the tax incentive leverages $3.4 billion in private investment. To be eligible for tax waiver, brownfields must be located in certain areas. (Source: http://www.epa.gov/swerosps/bf/bftaxinc.htm)

2.3.2 State and Local Programs

Tax Incremental Financing (TIF). TIF districts were originally established to redevelop the blighted or distressed areas by States or cities. Redevelopment authorities issue bonds to finance redevelopment costs upfront, and then use increased property or sales taxes to repay the bonds. TIF allows cities to initiate revitalization in distressed areas and does not require public funds. It may pay for new infrastructure, planning expenses, demolition, site assessment, and cleanup costs. However, TIF is criticized for that it lacks of evidence that the redevelopment would not happen without TIF (Simons 1998).

Tax Incentives. States often offer tax abatements or tax credits to allow developers to use projects' revenues for financing brownfield-related costs, such as remediation.

General obligation (GO) bonds. States, towns, cities, and other municipal authorities can issue municipal securities backed or secured by taxes. GO bonds are a major source of funds for infrastructure and redevelopment projects. Local governments can use GO bonds for site acquisition, remediation, and infrastructure enhancement. Unlike TIF, GO bonds will be counted against a jurisdiction's debt caps (Bartsch and Wells 2003).

Besides tax incentives and GO bonds, some States provide revolving loans, grants, technical assistance, and environmental insurance for brownfield assessment and remediation. Cities often provide zoning relief for brownfield projects to encourage redevelopment.

2.4 Pros and Cons of the Current U.S. Brownfield Financing Programs

Federal and State brownfield financing programs have provided financial assistance for brownfield cleanup and redevelopment and promoted economic development and environmental quality in the United States. Without financing programs, many brownfield projects will not happen, due to financial difficulties. Based on my review of current financing programs, I summarize their pros and cons below.

2.4.1 Pros of Current Brownfield Financing Programs

Making Decision Locally. Most federal brownfield financing programs are awarded to local governments or agencies, rather than individual developers. States or municipalities are more familiar with local situations than the federal government and have a better understanding of local priorities. It has an advantage that the money can be used wisely by allowing localities to make decisions on allocating brownfield funding.

Taking Costs into Consideration. When considering the remediation and assessment loans/grants, the administrating agencies often take into account of site size, the level and types of pollution, and other cost related information. This ensures that the funding is allocated based on the needs.

Removing the Perceived Risks. Lack of understanding of environmental risks is the major obstacle for brownfield redevelopment. More and more cities provide grants or forgivable loans for site assessment and make the assessment information available to potential developers. They make developers informed of the costs and the time for cleanup.

Reducing Debt Financing Costs. Cities also recognize the indirect costs of brownfield redevelopment by reducing developers' costs of debt financing costs and offering tax abatement. Many cities provide low or no interest loans for remediation costs and offer tax breaks in certain periods.

2.4.2 Cons of Current Brownfield Financing Programs

Failure to Consider the Full Costs. Currently most financing programs target direct costs of brownfield cleanup and redevelopment, i.e., assessment and remediation costs. Although some programs relieve the costs of debt financing, no financing programs take account of the full indirect costs of a brownfield project. For some projects, indirect costs may account for a larger percentage than direct costs.

No Consistent and Quantitative Funding Allocation Criteria. Most funding decisions are made locally by States or cities. No consistent and quantitative criteria have been established to evaluate the brownfield projects and allocate the funding. There are generally more than 20 brownfield financing programs for which a developer can apply. The financial resources for brownfield are scarce and scattered in different entities. Developers experience difficulties in tapping these resources. Based on my conversations with selected developers, they would rather not take the time to go through the long process for a small chance to get a small amount of money. Local governments could streamline the process by integrating all the brownfield financing programs into one or two agencies.

No Quantitative Measurement Public Benefits of Brownfield Redevelopment. Although many agency reports document the public benefits of brownfield redevelopment, they do not take into account public benefits, or, at least not quantitatively measure them when making funding decisions. Because of the limited funding sources, the financial resources should be allocated to the projects contributing the largest benefits to the society.

To sum up, current brownfield financing programs cannot cover the full extra costs of remediation and redevelopment. They are designed to remove uncertainties and lower the financial burdens for brownfield developers. The funding decision considers the actual costs and some indirect costs. Brownfield funding would be used more efficiently if it can develop a way to measure public benefits and streamline the application process.

Chapter 3

Optimal Brownfield Incentives

Brownfield redevelopment is basically an externality problem and requires government intervention. In this chapter, I begin with theoretical analyses and explore the optimal incentives for brownfield redevelopment. Based on the theoretical analyses, I provide a research hypothesis, methodologies, and data.

3.1 Theoretical Analyses – Optimal Government Intervention

The theoretical foundation for brownfield financing is externality and market failure.

3.1.1 Externality and Market Failure[2]

An externality is defined as "occurs when a decision causes costs or benefits to stakeholders other than the decision maker", but "the decision maker does not bear all of the costs or reap all the gains from his or her action" (Wikipedia). There are two types of externalities, i.e. positive and negative externalities. Pollution is a typical example of negative externality, which creates external costs to other stakeholders (e.g. health problems and pollution abatement costs), but the polluter may not compensate the costs

[2] 3.1.1 is adapted from Wikipedia. http://**en.wikipedia.org/wiki/Externality**

to the impacted stakeholders. The full cost to the society is larger than the cost to producers/polluters, due to the additional "external costs". Goods with negative externalities, if without government intervention, will be overproduced/over-consumed from the society's point of view. Education is a typical kind of goods with positive externalities. It brings more benefits to the society than the tuitions. Goods with positive externalities, if without government intervention, will be under-produced or under-consumed from society's point of view. (Wikipedia)

When there are needs for real estate, a developer may face the choices of developing either a greenfield or a brownfield. From the social perspective, for greenfield development, developers take natural habitats or agricultural lands, which otherwise can provide environmental benefits to the society, such as bio-diversity, clean air, and pollution abatement. Greenfield development, as a kind of goods with negative externalities, would be over produced without appropriate government intervention. Brownfield redevelopment not only saves greenfields, but it also provides other social benefits, such as environmental and health benefits for communities. If these external benefits are not subsidized by the government, brownfield redevelopment would be under produced.

From the perspective of the society or welfare economics, both kinds of externalities will lead to the economy deflecting from the socially optimal status, i.e., incurring a market failure. In greenfield development, due to the underestimated costs (external costs), the market price (P_0) is lower and the quantity (Q_0) is higher than the optimal levels (Figure 3.1). In brownfield redevelopment, due to underestimated utilities (external benefits), the market price (P_0) is higher and the quantity (Q_0) is lower than the optimal levels (Figure 3.2). (Wikipedia)

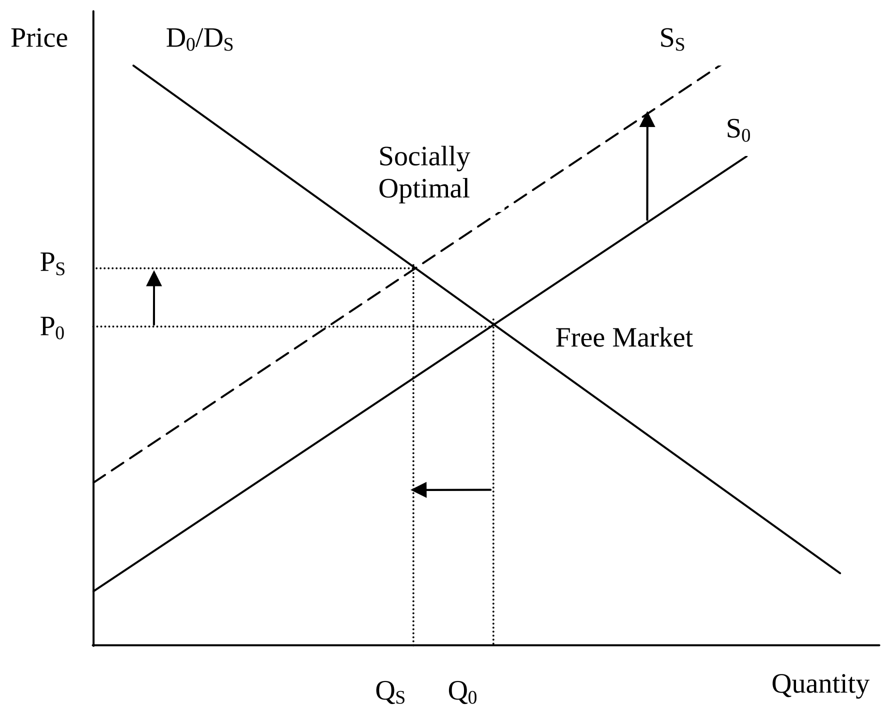
To correct for market failures, there are usually two types of solutions, i.e. private negotiation and public intervention. Ronald Coase argued that individuals could settle agreements through negotiations. For example, the producers of external benefits can bargain with the beneficiaries (the recipients of external benefits) and receive compensations from them. However, the Coase Theorem is contingent upon the following conditions: "(1) property rights are well defined; (2) people act rationally; (3) transaction costs are minimal" (Coase 1960; Wikipedia). In brownfield or greenfield development, it is evident that these conditions are not satisfied. For example, it is very difficult to identify who receive the benefits of brownfield redevelopment. Also, the transaction costs for negotiating with the beneficiaries and collecting the payments are very high. Governmental intervention can take several forms: tax, subsidies, and quantity control. For goods with negative externalities, such as greenfield development, the government can charge a pollution/resource tax (P_S – P_0) on the producer, thus the supply curve shifts up by $P_S – P_0$. The new equilibrium will be equal to the socially optimal status. Alternatively, government can identify the optimal quantity Q_S and set the quota at Q_S (figure 3.1). For goods of positive externalities, such as brownfield redevelopment, governments can subsidize the producer by $P_S – P_0$ and shift the supply curve down by $P_S – P_0$. The new equilibrium reaches the socially optimal status. Similar to the previous situation, quantity control can lead to the same effect (Figure 3.2).

Government intervention has its own problems and may result in government failure. On the one hand, it is very hard to calculate the optimal tax, subsidy, and quota, because the external benefits or costs cannot be observed in the market and are thus difficult to quantify. On the other hand, it may cause economic inefficiency by public policy, such as rent-seeking and shortsightedness effect.

(Source: http://en.wikipedia.org/wiki/Government_failure)

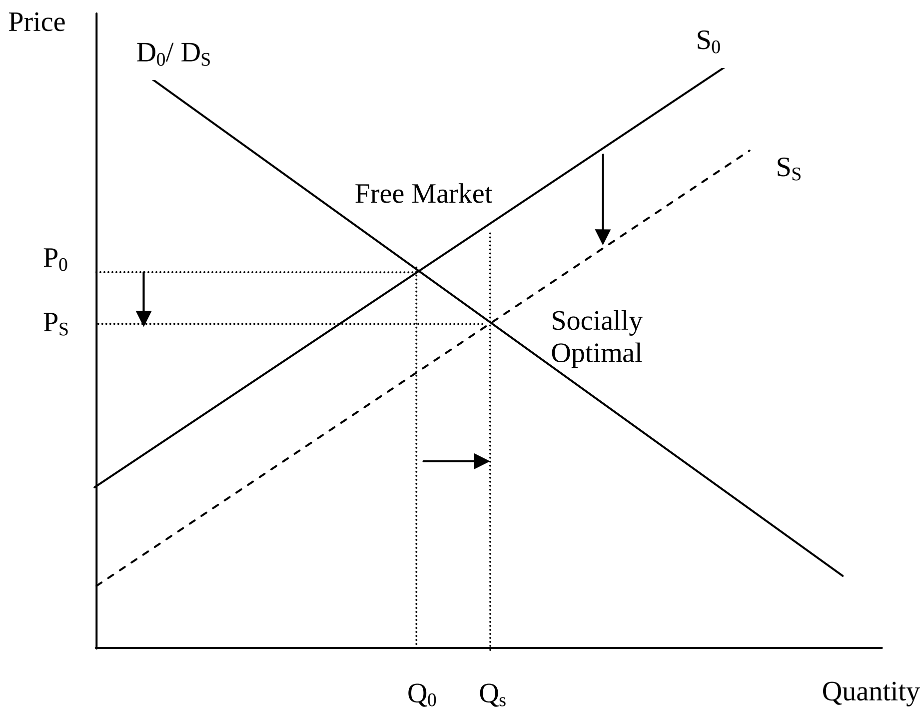
Brownfield redevelopment contributes to the society with many benefits without being compensated (positive externality). Brownfield redevelopment would be undersupplied without government intervention. Fortunately, many brownfield financing programs have provided subsidies, thus increased the supply of redevelopment. Theoretically, if these subsidies are equal to the external benefits the brownfield redevelopment creates, they are successful in correcting market failure.

Figure 3.1: Greenfield Development



Source: edited by the author.

Figure 3.2: Brownfield Redevelopment



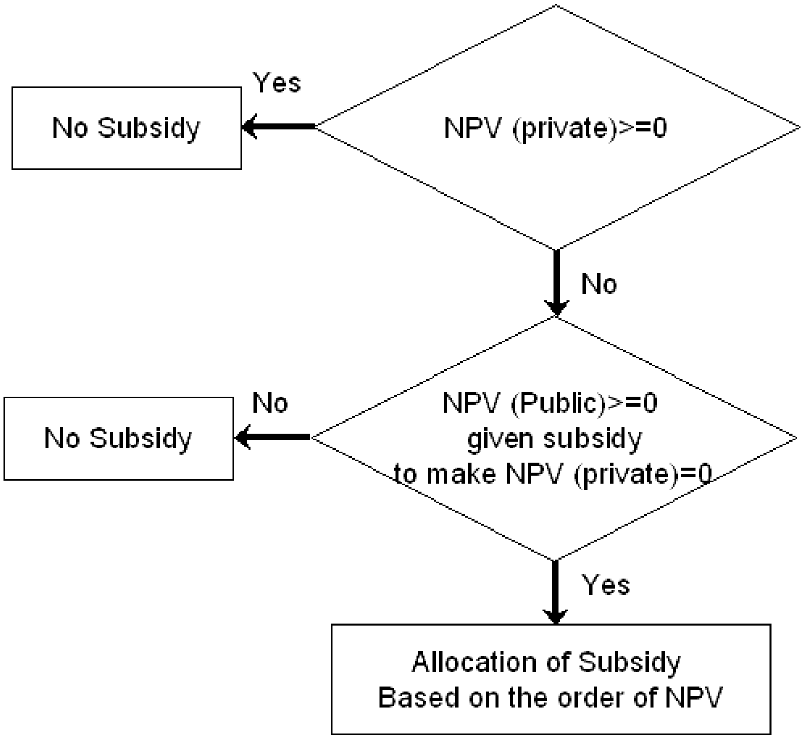
P_0: Private Price; P_S: Social Optimal Price; S_0: Private Supply Curve; S_S: Social Supply Curve; Q_0: Private Quantity; $Q_{S:}$ Social Optimal Quantity.

Source: edited by the author.

3.1.2 An Optimal Funding Allocation Mechanism

In the real world, the government does not have the financial resources to subsidize all the positive externality. I design a brownfield funding-decision flow chart, which maximizes the social returns within the public-funding limit (Figure 3.3). First, if a brownfield project has a positive or zero private net present value (NPV), governments should not fund it. Many brownfield redevelopment projects have been funded by developers themselves without public funding. Second, if the private NPV is negative, we can calculate the amount of subsidies to make private NPV zero. Based on the amount of subsidies (investment costs) and public benefits (revenues) from a brownfield project, the net present social value (NPSV) can be derived. If a project's NPSV is negative, governments should not fund the project. If a project's NPSV is larger or equal to zero, governments should consider its funding application. Finally, if the available funding is less than the required amount based on a social NPV analysis, then the funding allocation should give priorities to those projects with larger NPSVs.

Figure 3.3: Proposed Optimal Brownfield Funding Decision-Flow Chart



Source: the author.

NOTE: NPV (PUBLIC) IS SAME AS NPSV (NET PRESENT SOCIAL VALUE).

3.2 Research Hypothesis

In this study, I examine if the brownfield funding is allocated in a way to correct market failure, based on the optimal framework that I proposes in Figure 3.3. Given the limitation of available brownfield funding, the funding should be allocated to the projects that both need public money and generate the maximum public benefits. Due to confidentiality, private NPV (the first step in the flow chart) and/or the subsidy to make private NPV zero are difficult to obtain. And I do not have sufficient data to test if funded projects have larger NPSVs than not-funded projects. I can only investigate if NPSVs of funded brownfield projects are positive.

My research hypothesis is that current brownfield incentives are sub-optimal: the funding decision does not consider NPSV so that some funds are allocated to projects with negative NPSVs.

3.3 Methodologies

I use case studies and benefit-cost analysis to test my hypothesis. I test whether the NPSVs of selected cases are negative.

Case Studies

To support my hypothesis, I select three brownfield cases in Massachusetts to examine the effectiveness of brownfield incentives. I also obtain further background information from local planning agencies in the three towns. By examining the social returns of three brownfield redevelopment cases, I intend to test my hypothesis.

Benefit-Cost Analysis

Benefit-costs analysis is often used to evaluate the public projects. In this study, I modify it to evaluate the public benefits and costs of brownfield projects from a social perspective.

To quantify the social return of a brownfield project, I use DCF (Discounted Cash Flow) analysis. I calculate the NPSV and Internal Rate of Return (IRR) of brownfield projects, based on the cash flow of social benefits and costs (Brealey and Myers, 2006). The government should not sponsor negative NPSV projects and should prefer projects with larger NPSVs. Also, the government should not subsidize the projects with IRRs smaller than its “opportunity cost of capital”.

$$NPSV = C_0 + \frac{CF_1}{1+r} + \frac{CF_2}{(1+r)^2} + \frac{CF_3}{(1+r)^3} + \ldots \frac{CF_H}{(1+r)^H} + \frac{PV_H}{(1+r)^H}$$

PV_H: horizon value; r: opportunity cost of capital.

$$NPSV = C_0 + \frac{CF_1}{1+IRR} + \frac{CF_2}{(1+IRR)^2} + \frac{CF_3}{(1+IRR)^3} + \ldots \frac{CF_T}{(1+IRR)^T} = 0$$

3.4 Measuring Social Investment Costs and Benefits of Brownfield projects

In social benefit-cost analyses, the key step is to identify and measure public benefits and public investments (public costs) of brownfield projects.

3.4.1 Rationale of Selecting Benefits and Costs

The benefits of brownfield redevelopment covered in various literature encompass the increase of tax revenues, job growth, environmental and health benefits, efficient use of existing infrastructure, transportation, etc. The purpose of this study is to identify those social benefits and costs that are not reflected in the free market and so entail government intervention by generating incentives. Hence, I intentionally exclude some benefits and costs associated with brownfield redevelopment that are either not valid in social perspective or already internalized. For example, a tax-base increase and job creation are benefits to the community, but greenfield projects could produce similar benefits. They are no more than a transfer of benefits from one place to another. Considering that some benefits are controversial, I focus my benefit-cost analysis on easily identified benefits and costs.

3.4.2 Measuring Public Costs of Brownfield Redevelopment

In theory, the social investment costs of brownfield redevelopment should be the minimum amount of funding to make the private NPV equal to zero. In the real world, governments allocate the funding based on the direct costs of brownfield redevelopment, which may differ from the optimal level of funding.

The real public costs of a brownfield project are comprised of two parts: various sources of public funds that a brownfield project received and the social costs of the redeveloped property. The first one is straightforward and easy to measure. A redeveloped property may increase the demand for infrastructure and create traffic, noises, and new environmental problems. Considering the complexity of measuring the second part of costs, I only derive public costs of a brownfield project by adding the public funds invested in the project.

3.4.3 Measuring Public Benefits of Brownfield Redevelopment

Benefits are relatively controversial and difficult to measure, because many of them cannot be directly observed in the market. In this study, I use hedonic models to measure the public benefits of brownfield redevelopment and focus on local residents' benefits.

3.4.3.1 Composition of Public Benefits

Brownfield redevelopment returns to the society with green space conservation, health and environmental benefits, and control of urban sprawl.

Green Space Conservation

Brownfield redevelopment mitigates the development pressure on greenfields and preserves agricultural and natural habitats. One acre of a reclaimed brownfield saves 4.5 acres of green space (White House Council on Environmental Quality 2004). The monetary values of green space saving may be of different values at different locations, based upon the willingness-to-pay for green space. Analysts generally use contingent valuation (CV) to measure the willingness to pay for environmental goods.

Health Benefits

Remediation/redevelopment reduces health risks posed by contaminants to the community and the workers in the impact region. An analyst can measure the health benefits, using either the real costs of health risks or the costs of clean-up (Hamilton and Viscusi 1999). The first method is ideal, but it is scientifically controversial to translate environmental risks to the number of deaths or diseases averted; and ethically controversial to translate the averted health risks into monetary values. The remediation cost data are easier to identify, but the costs can not reflect the real environmental and health risks.

Other Benefits

Brownfield redevelopment encourages compact urban development and controls urban sprawl. It can reduce commuting costs, including the direct cost of commuting and the externality associated with travel (e.g. congestion, emission, noise, safety, and accidents) (Sousa 2002).

3.4.3.2 Alternative Categorization of Benefits and Measurement

It is difficult and time-consuming to calculate the various public benefits illustrated above. In this study, I employ an alternative way to categorize and measure public benefits. Based on the recipients, I categorize the public benefits of brownfield redevelopment into three types, i.e., the benefits for local residents, local business, and the general public. Local residents benefit from improved views and environmental and health risks reduction. Local businesses gain the increased revenues and their employees enjoy health and aesthetic benefits from brownfield redevelopment. The general public receives the benefits from green-space saving.

Local residents' benefits can be observed from the neighborhood housing appreciation, because local residents would like to pay more for improved neighborhood due to brownfield redevelopment. I use hedonic models to measure the housing-price appreciation associated with brownfield redevelopment.

Local businesses' benefits can be calculated in a similar way, but the hedonic model should build on commercial properties to reflect increased revenues and on wages to reflect increased attractiveness of working place. Due to data constraints, I do not include these benefits.

The general public's benefits can be measured by contingent valuation (CV), which builds on the survey and questionnaires to estimate people's willingness to pay. I do not include CV, because of the limitation of resources.

To sum up, I include all the public brownfield funds, such as tax credits, grants, low or no interest loans, etc., in social investment costs. These funds can be seen as the public investment on brownfield redevelopment. I only take into account the local residents' benefits in public benefits, due to the constraints of data and resources. I intentionally exclude some benefits associated with brownfield redevelopment that do not exist from the social perspective, such as tax and job creation.

3.5 Hedonic Model

In this study, as noted earlier, I use hedonic models to measure neighborhood housing price appreciation due to brownfield redevelopment, which represents local residents' benefits from brownfield cleanup and redevelopment. The social benefit-cost analysis is the core part of this study, and the measurement of public benefits is the key of the benefit-cost analysis. Hence, I detail the hedonic model methodology and steps in a separate part.

3.5.1 The Principles of Using Hedonic Model

Many scholars use the hedonic model to identify the distance-related effects of hazardous sites on housing prices (e.g. Kiel and Zabel 2001). Housing prices can be estimated by structural, neighborhood characteristics, inflation and other factors. By controlling all the independent variables except for the variable of distance to a brownfield, I can measure the price appreciation due to brownfield cleanup and redevelopment.

I measure the housing-price appreciation associated with brownfield cleanup and redevelopment as the discounted value of future environmental, aesthetic, and health benefits. Local residents factor the annual costs, such as health risks, aesthetic disamenity, and environmental risks, by discounting them into present values when they evaluate a house purchase close to a brownfield. My hypothesis is that a brownfield has negative impacts on local residents so that the price-distance slope is positive, reflecting the local resident's willingness to pay for living farther away from the brownfield, and brownfield redevelopment will lower the price-distance slope, because it provides local residents with health, environmental, and aesthetic benefits (or reduction of health, environmental, aesthetic costs). .

3.5.2 Data Sources

I will use the following data for completing the case studies: (1) Sale transaction data. The Warren Group (2006) provides single-family house sale transaction data, which include the addresses of houses, sale prices, year of built, year of sold, number of bathroom and bedroom, living area, lot size, property tax, and types of structure. I do not include neighborhood characteristics, because the research areas I delineate are generally within a 0.5-mile radius. I assume that neighborhood characteristics are homogenous in the area. (2) Map of the impact area for each brownfield. Based on the address of a brownfield, I identify the impact region (study area). From my interviews with residents and urban planners in the area, I have found that a 0.5 to 1 mile radius generally covers the impact area. (3) The years that brownfields are abandoned, remediated, and redeveloped. These dates are vintage years for the impacts of housing values, and I use them to identify the time range to match available sales-transaction data. (4) General background information on the brownfield sites and neighborhoods. Background information includes aerial photos, site history, redevelopment project background, census data, etc. I use all the information to help understand the neighborhood and impacts of cleanup and redevelopment.

3.5.3 Model Specification

The hedonic model depicts the relationship between property values and housing characteristics, as expressed in the following formula:

$$Ln\ (Price) = f\ (X_{1i}, X_{2i}, \ldots, X_{ni}) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.1)$$

where Ln(Price) is the natural logarithm of the sale price of the house and X series variables are explanatory variables representing housing characteristics. They include structural variables, inflation index, and distance variables. Below is a list of independent variables used for hedonic models.

distance: distance from transaction address to the brownfield in meters;

dist_sq: the square of distance to brownfield;

Lotsize: lot size in 1000 sq feet;

Liv_sf: living area in 1000 sq feet;

bedroom: number of bedrooms;

bathroom: number of bath rooms;

age: age of house in years;

style_X: dummy variables for house styles, such as Cape Cod, colonial, ranch, raised ranch, garrison and bungalow;

sold_year: dummy variables for the different years that the house was sold.

3.5.4 The Process of Model Building

I conduct the basic process of hedonic model building in four steps.

Step1: Data Collection

First, I interview urban planners, visit the site, and obtain related redevelopment/remediation data. I obtain housing sale transaction data within the impact region ranging from 3-5 years before remediation announcement date to 3-5 years after redevelopment completion date, provided by The Warren Group. In this study, I focus on the neighborhood with a high concentration of single-families, which makes the models easier to build.

Step2: Data Clean and Preliminary Analysis

The second step is to prepare for regression analyses, including eliminating outliers, calculating the distances, examining the distribution of each variable, and deciding the formats of the variable (original or dummy, linear or quadratic).

I calculate Age by subtracting the year built from the year sold. I transform year sold into a category variable, reflecting annual housing-price inflation in the area. When I transform Styles into category variables, I exclude the category with the largest number of observations.

I select the data period to cover a span from at least 3 years before remediation or immediately after abandon year to 3 years after remediation. My purpose is to accumulate enough data to capture price impacts. I use ArcGIS to calculate the distances from single-family houses in the impact region to the brownfield. First, I geocode all the house addresses by U.S. Streetmap, and then use proximity analysis in ArcGIS software to calculate the straight-line distances between each house to the brownfield.

I also use ArcGIS, US Street Map, and image files to analyze the topography and determine the appropriate impact region, which I designate by a certain radius from the brownfield site. To simplify the model, I usually select housing transaction data in the same town as the brownfield in order to save the neighborhood variables. By considering local residents' perception of environmental risks, topography, and transportation convenience, I determine a radius for each case. For example, I do not consider housing transactions isolated from a brownfield by natural/artificial barriers, such as lakes, mountains, railroads, and highways. Generally speaking, more people perceive the risks from brownfields with visible pollution, good publicity, and good accessibility. I also use statistical analyses to test the impact region.

I examine correlations between independent variables to prevent the collinearity problem by excluding one of two variables with high correlations. Besides selecting the independent variable, I decide which of the following formats to use for these variables, linear or quadratic, and dummy or quantitative variable. For example, the relationship between lot size and natural logarithm of the price is better depicted in quadratic rather than linear form. In this case, I need to add both lot size and the square of lot size in the formula.

Outliers could be recording errors and non arm-length transactions. I examine the distribution of sale price and exclude non arm-length transactions. I develop other simple rules to avoid recording errors, such as filtering the data of negative ages (generally recording errors of years built).

Step 3: Data Analyses

I conduct regression analyses separately before the remediation and after redevelopment completion. I perform two additional regressions to (1) test whether the brownfield has negative housing price impact before remediation; (2) test the hypothesis that brownfield cleanup and redevelopment have significant positive impacts on housing prices; and (3) calculate the housing-price improvements due to brownfield redevelopment.

Step 4: Result Interpretation

The slope before remediation should be positive. The slope reflects the local residents' willingness-to-pay for living farther away from the undesirable site (brownfields). I assume that the difference of distance gradients is attributed to brownfield redevelopment's impacts on housing price. Theoretically, the price-distance slope before remediation is steeper than that before remediation. And the difference between the two gradients can be seen as the housing price appreciation due to brownfield cleanup and redevelopment.

3.6 CONCLUSION

An optimal brownfield funding-allocation mechanism should: (1) NOT fund projects with private NPV>=0; (2) consider projects with positive NPSV; (3) prefer projects with larger positive NPSV. My research hypothesis is that brownfield funds are allocated to some projects with negative NPSV. I use social benefit-cost analyses to test the hypothesis by evaluating three cases studies in Massachusetts. The social costs are the brownfield funds invested in a project. The public benefits are the benefits to local residents, local business, and the general public. I only consider the first benefits in this study and employ hedonic models to measure indirectly local residents' benefits from brownfield redevelopment.

Chapter 4

Case Studies in Massachusetts

In this chapter, I investigate three brownfield redevelopment cases in Massachusetts, selected from successful stories in EPA region 1 website. I employ hedonic models to measure the housing price effect due to brownfield cleanup and redevelopment, which reflects local residents' willingness to pay for the improvement of environmental quality and health benefits. Based on the estimated public benefits, I calculate the return for government investment (brownfield funds) and evaluate if the investment is justified by the public benefits received.

4.1. Case One: Brockton, MA

Table 4-1: Highlights of Former Shoe Factory Site in Brockton

Redevelopment End Use	corporate headquarters
Site Location	173 Spark Street, Brockton, MA 02302
Size	6 Acres
Pollution Types	n/a, typical shoe factory pollutants
Abandon Date	1994
Remediation Start Date	2002
Remediation Finish Date	2002
Total Government Funds	$463,947
No. of Transaction Data Available	1,830

Source: EPA Region 1 Brownfield website.
http://www.epa.gov/newengland/brownfields/success/brockton_tba.htm

4.1.1 Site Description

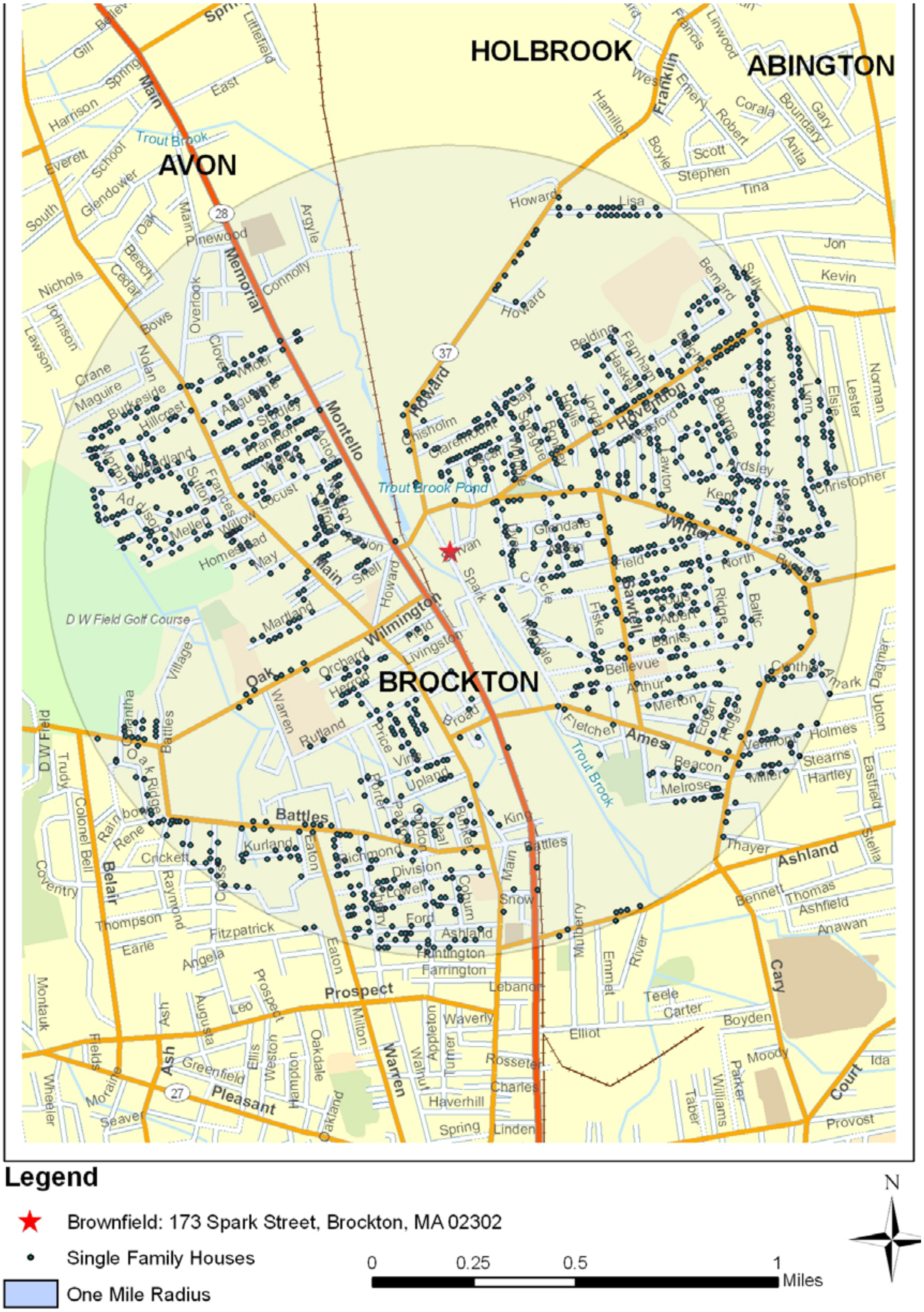
The Brockton brownfield site (Table 4-1 and Figures 4-1 and 4-2) was a redevelopment of an abandoned industrial site. The six-acre site on 173 Park Street had been vacant since a former shoe factory burned down in 1994. According to the City of Brockton, the site is located in an "economic corridor" of Brockton, where many other successful firms and the Montello commuter rail station are located.

The city secured Environmental Protection Agency (EPA) assessment funds of $50,025 to complete environmental assessment Phase 1 in 1997 and Phase 2 in 1999. The city sold the property to Fleet Environmental Services in 1999 and reached an agreement of Tax Incremental Financing (TIF) with the new owner. Fleet transferred the property to David Gooding, Inc (DGI) in 2002. And the city modified the TIF agreement so that DGI will receive a property-tax reduction of $321,422 over 13 years and is eligible to claim a 5% investment tax credit from the State. In 2004, DGI moved into the new 60,000-square-feet building as its corporate headquarters and warehouse distribution facility after the lot was vacant for ten years.

(Source: http://www.epa.gov/newengland/brownfields/success/brockton_tba.htm)

The GIS map shows the location of the brownfield, single-family houses in a one-mile radius, streets, highways, and context (Figure 4-1). The photo and air photo show the redeveloped site and its context (Figure 4-2).

Figure 4-1: ArcGIS Map of Brockton, One-Mile Radius of the Brownfield Site



Source: ArcGIS, U.S. StreetMap 9.1; Single-family addresses by Warren Group

Figure 4-2: Photograph and Air Photograph of the Redeveloped Site in Brockton (DGI Headquarters)

Source: the City of Brockton, and Google Earth 2006.

4.1.2 Data Set

The Brockton data set in Brockton incorporates 1830 single-family housing transactions within a one-mile radius of the target brownfield site (Figure 4-2), with the sale years ranging from 1994 to 2006. The period covers abandonment, remediation, and post-redevelopment phases. The number of samples is large enough to support statistical analyses. Descriptive statistics for all the variables used in the model are shown in Table 4-2.

Table 4-2: Descriptive Statistics for the Brownfield in Brockton

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
PRICE	1830	50,200	540,000	153,987	76,234
DISTANCE	1830	201.8	1607.0	1036.7	369.3
DIST_SQ	1830	40,716	2,582,392	1,211,098	738,928
BATHROOMS	1830	1	4	1.23	.391
BEDROOMS	1830	1	6	2.99	.673
LOTSIZE	1830	2.2	160.3	10.2	8.2
LOTSIZE2	1830	4.7	25696.4	171.0	983.3
AGE	1830	0	229	52.55	27.81
style_colo	1830	0	1	.30	.458
style_bngl	1830	0	1	.10	.297
style_cape	1830	0	1	.08	.269
style_split	1830	0	1	.16	.367
style_multiunit	1830	0	0	.00	.000
style_rdranch	1830	0	1	.09	.291
style_twofam	1830	0	1	.00	.023
SOLD_95	1830	0	1	.07	.256
SOLD_96	1830	0	1	.07	.263
SOLD_97	1830	0	1	.08	.267
SOLD_98	1830	0	1	.08	.270
SOLD_99	1830	0	1	.09	.283
SOLD_00	1830	0	1	.09	.284
SOLD_01	1830	0	1	.08	.274
SOLD_02	1830	0	1	.08	.279
SOLD_03	1830	0	1	.08	.270
SOLD_04	1830	0	1	.09	.290
SOLD_05	1830	0	1	.10	.298
SOLD_06	1830	0	1	.01	.109
Valid N (listwise)	1830				

Source: Author's calculations.

4.1.3 Data Analyses

The basic procedure of data analyses is illustrated in chapter 3. Below are the major results of data analyses.

Price. To exclude non arm-length transactions, I examine the distribution of the price. I set a $50,000 threshold so as to exclude 6% of the smallest prices. Also, I test the excluded prices by using a scatterplot of price and distance. Most of excluded observations are well distributed in the distance range.

Distance. I select a one-mile radius to cover the impact region. I realize that Montello commuter rail station is only 0.1 mile away from the brownfield site. Although the rail station has a large impact on housing prices, I do not factor it into the model for two reasons. The distances from the station to the houses are very similar as to the brownfield site. The rail station's impacts within one mile are assumed to be homogenous, i.e., nearly same price impacts within a one-mile radius. And when calculating the difference of price-distance gradients, the effect of commuter rail station can be canceled out. I note that the price-distance slope before remediation may be flattened by the positive impacts of the commuter rail station.

Living area, bathroom, and bedroom. The Pearson correlation between living area and bedroom is 0.493 and is significant at the 0.01 level. I regress ln(price) on living area and bedroom separately. The number of bedrooms results in a more significant coefficient, therefore, I exclude the number of bedrooms.

Lot size and age. They basically exhibit a linear form, although the coefficient for the square of lot size is significant.

4.1.4 Review of Regression Results

Through independent regressions and collinearity tests, I select independent variables and their forms. I use SPSS to obtain regression results for the entire data set (Table 4-3). The regression model achieves a reasonably good result. The R square indicates that 80.6% of variation in ln(price) can be explained by all the independent variables listed in Table 4-3. Most independent variables are statistically significant at 95% confidence level.

- Housing price has appreciated by 126% since 1994. This is in line with the revitalization in this region, such as the opening of public schools and commuter rail stations and taming crime rates.

- Having one more bathroom creates a 9.4% of price premium, while one more bedroom provides 4.7% of price premium.

- Houses of ten years older lose an average of 2.13% in price.

- A lot size of 77,722 square feet provides the largest price premium of 500%, while a lot size of 1,000 square feet only furnishes a 6% .price premium.

- Colonial, Cape Cod, and Raised-Ranch styles houses sell for higher than average prices, 5.94%, 9.77%, and 12.1%, respectively.

- The coefficient for distance is 0.02026% and is significant at the 95% confidence interval, which means the average price of houses 100 meters away from the brownfield increases by 2.025%, considering the quadratic coefficient.

Table 4-3: Regression Results for the Brownfield in Brockton

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.899	.809	.806	.218

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	10.952	.053		204.934	.000
	DISTANCE	2.026E-04	.000	.151	2.518	.012
	DIST_SQ	-1.03E-07	.000	-.154	-2.561	.011
	BATHROOMS	9.378E-02	.014	.074	6.513	.000
	BEDROOMS	4.717E-02	.009	.064	5.473	.000
	LOTSIZE	5.996E-03	.001	.099	4.445	.000
	LOTSIZE2	-3.60E-05	.000	-.072	-3.326	.001
	AGE	-2.13E-03	.000	-.120	-6.179	.000
	style_colo	5.942E-02	.020	.055	2.938	.003
	style_bngl	3.571E-02	.023	.021	1.543	.123
	style_cape	9.772E-02	.022	.053	4.545	.000
	style_split	2.801E-02	.018	.021	1.595	.111
	style_rdranch	.121	.021	.071	5.833	.000
	style_twofam	-.130	.221	-.006	-.591	.555
	SOLD_95	1.010E-02	.027	.005	.376	.707
	SOLD_96	-2.54E-03	.026	-.001	-.096	.923
	SOLD_97	9.487E-02	.026	.051	3.610	.000
	SOLD_98	.204	.026	.111	7.786	.000
	SOLD_99	.328	.026	.188	12.826	.000
	SOLD_00	.506	.026	.291	19.810	.000
	SOLD_01	.697	.026	.387	26.840	.000
	SOLD_02	.853	.026	.480	33.087	.000
	SOLD_03	1.014	.026	.554	38.671	.000
	SOLD_04	1.112	.025	.652	43.780	.000
	SOLD_05	1.192	.025	.718	47.465	.000
	SOLD_06	1.256	.050	.277	24.957	.000

a. Dependent Variable: LN_PRICE

Source: Author’s calculations.

4.1.5 Comparison Between Before and After Remediation Effects

I perform two additional regressions to (1) test whether the brownfield has negative housing price impact before remediation; (2) test the hypothesis that brownfield cleanup and redevelopment have significant positive impacts on housing prices; and (3) calculate the housing-price improvements due to brownfield redevelopment.

I split the data set into two data sets, i.e., 1994 to 2001 and 2002 to 2006, which covers the pre- and post-remediation periods. They consist of 1,158 and 623 cases, respectively. For both of the two datasets, I perform regressions by using the same variables as for the whole sample. The first data set captures the housing price before remediation, when brownfields should have negative price impacts. The second one reflects housing prices in the post-remediation period.

The R square results in Tables 4-4 and 4-5, show that the first regression explains 61.4% of variation in the natural logarithm of housing prices, and the second one explains 51.6% of variation. Both estimates are less precisely than the regression for the whole data set. One explanation may be the smaller number of observations, especially for the second dataset. Another is that the regressions have fewer independent variables than other hedonic models. The estimation errors are magnified in small datasets.

Table 4-4: Regression Results for the Brownfield in Brockton, 1994 to 2001

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.788	.620	.614	.205

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	10.956	.061		178.451	.000
	DISTANCE	2.216E-04	.000	.249	2.382	.017
	DIST_SQ	-1.05E-07	.000	-.235	-2.241	.025
	BATHROOMS	.105	.017	.125	6.243	.000
	BEDROOMS	2.799E-02	.011	.054	2.659	.008
	LOTSIZE	5.919E-03	.002	.160	3.882	.000
	LOTSIZE2	-2.20E-05	.000	-.074	-1.853	.064
	AGE	-1.57E-03	.000	-.130	-3.660	.000
	style_colo	3.512E-02	.025	.048	1.430	.153
	style_bngl	7.896E-03	.029	.007	.276	.782
	style_cape	9.248E-02	.026	.074	3.578	.000
	style_split	3.428E-02	.020	.040	1.693	.091
	style_rdranch	.134	.024	.121	5.485	.000
	style_twofam	-.122	.209	-.011	-.585	.559
	SOLD_95	1.260E-02	.025	.012	.499	.618
	SOLD_96	-3.69E-03	.025	-.004	-.148	.882
	SOLD_97	9.591E-02	.025	.095	3.876	.000
	SOLD_98	.205	.025	.207	8.338	.000
	SOLD_99	.331	.024	.347	13.712	.000
	SOLD_00	.501	.024	.528	20.771	.000
	SOLD_01	.697	.024	.711	28.465	.000

a. Dependent Variable: LN_PRICE

Source: Author's calculations.

Both of the hypotheses are verified. The price-distance gradient is positive and significant before remediation. It represents local residents' willingness to pay for living farther away from the site. The price-distance gradient is positive and significant during

Table 4-5: Regression Results for the Brownfield in Brockton, 2002 to 2006

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.727	.529	.516	.134

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	11.859	.060		196.971	.000
	DISTANCE	1.870E-04	.000	.357	2.106	.036
	DIST_SQ	-9.81E-08	.000	-.375	-2.209	.028
	BATHROOMS	.100	.016	.203	6.429	.000
	BEDROOMS	2.890E-02	.009	.108	3.284	.001
	LOTSIZE	1.349E-02	.004	.335	3.494	.001
	LOTSIZE2	-2.65E-04	.000	-.213	-2.314	.021
	AGE	-1.81E-03	.000	-.259	-5.280	.000
	style_colo	8.825E-02	.021	.214	4.186	.000
	style_bngl	6.279E-02	.024	.102	2.662	.008
	style_cape	7.060E-02	.022	.104	3.176	.002
	style_split	2.681E-02	.020	.048	1.362	.174
	style_rdranch	.124	.022	.184	5.614	.000
	SOLD_03	.140	.016	.298	8.519	.000
	SOLD_04	.236	.016	.533	14.922	.000
	SOLD_05	.304	.016	.707	19.466	.000
	SOLD_06	.325	.031	.311	10.462	.000

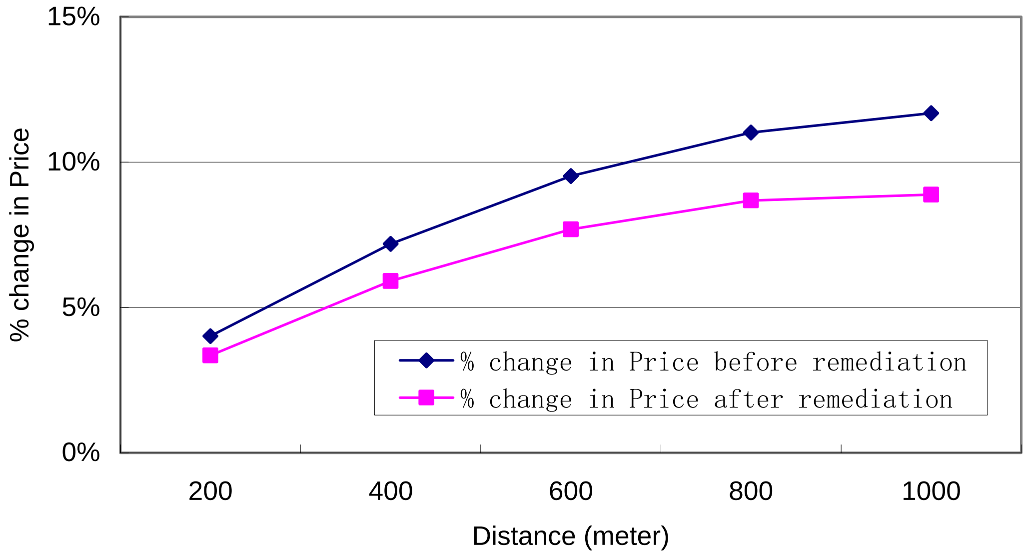
a. Dependent Variable: LN_PRICE

Source: Author's calculations.

2002 to 2006, which means the residual negative impacts after remediation. However, the price-distance gradient decreases after remediation. The difference in the price-distance slopes reflects the remediation/redevelopment impacts on housing prices.

Based on the difference of the slope of price-distance, I calculate the price change for each single-family house within the one-mile radius. I derive house prices in 2003 by multiplying the most recent transaction price by the relevant inflation index. The total of house price appreciations of 1,365 single-family houses[3] due to brownfield redevelopment within one-mile radius of the brownfield is $ 8,733,438 (2004 dollars).

Figure 4-3: Price-Distance Slope Before and After Remediation



Source: Author's calculations.
Note: the percent difference here is actually % in lnPrice, but when the percentage is less than .1, the two numbers are close.

4.1.6 Discounted Cash-Flow Analysis for Brownfield Investment

Based on the public benefits and public investment, I perform a social benefit-cost analysis. On the social-cost/investment side, there are three public funds for this project. EPA allocated an assessment fund of $50,525 in 1999. The city offered a property-tax reduction of $321,422 over 13 years, i.e., $24,725 per year from 2003 to 2016, and a 5% investment tax credit. I assume that DGI allocated its total investment $3.7 million evenly in two years of the development period. The available tax credits in

[3] Some houses are sold twice during 1994 to 2006. So there are 1830 transactions, which are more than the number of houses.

2003 and 2004 are $23,125 (3,700,000*0.05*25%/2) annually (Table 4-6). On the social-benefits side, local residents' benefits are $8,733,438 in 2004 dollars.

Based on the net social benefits, I derive that the Internal Rate of Return (IRR) for this social investment is 180%. It is much higher than average returns for public projects. The Net Present Social Value (NPSV) is equal to $6.5 million. If the effect for all of houses is realized in 2006, the IRR will drop to 109%, while NPSV is $6.4 Million. I perform a further stress test by using only houses within a half-mile. The public benefits drop to $1.73 million, while the IRR is 57% and NPSV is $0.91 million.

Table 4-6: Discounted Cash Flow for Brockton Brownfield

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	…
	0	1	2	3	4	5	6	7	8	…
Assess Fund	(50,025)									…
Property Tax Reduction					(24,725)	(24,725)	(24,725)	(24,725)	(24,725)	…
Tax Credit					(23,125)	(23,125)				…
Public Benefits						8,733,438				…
Net Social Benefits	(50,025)	0	0	0	(70,975)	8,662,463	(24,725)	(24,725)	(24,725)	…
IRR	180%									…
NPV	6,555,078									

Source: Author's calculations.

4.1.7 Conclusion

This brownfield has negative impacts on housing price before remediation. Brownfield redevelopment has generated benefits to local residents, which are reflected in housing market. This case verifies the hypothesis of this study. From the social perspective, NPSV is positive and public funds can be strongly justified by its social benefits.

4.2 Case Two: Gardner, MA

Table 4-7: Highlights of the 30 Wickman Drirve Site in Gardner, MA

Redevelopment End Use	affordable housing
Site Location	30 Wickman Drive, Gardner, MA 01440
Size	1.1 acres
Pollution Types	EPHs, SVOCs, and lead
Abandon Date	1995
Remediation Start Date	2002
Remediation Finish Date	2002
Total Government Funds	$212,000
Available Transaction Data	300

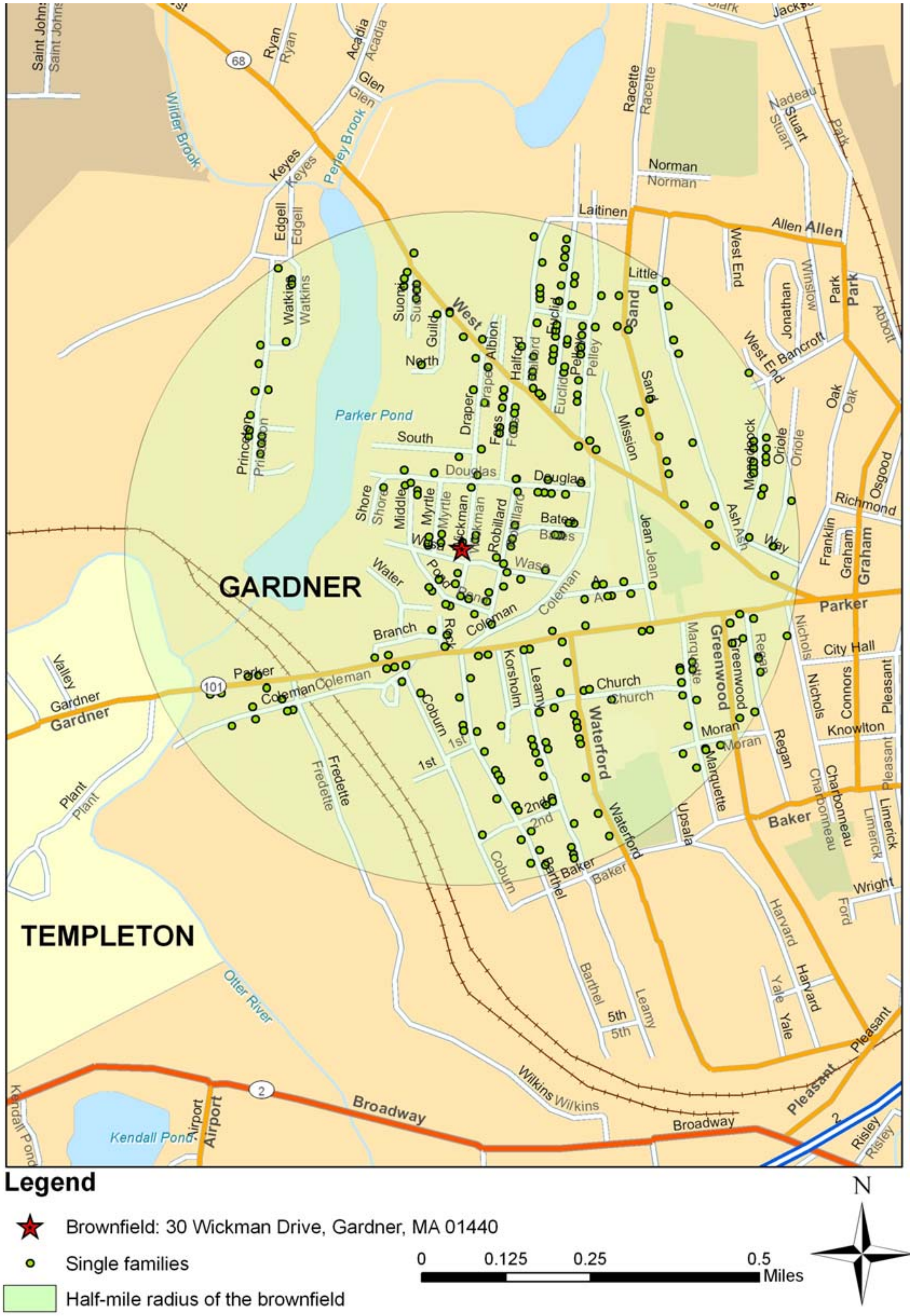
Source: EPA Region 1 Brownfield website.
http://www.epa.gov/newengland/brownfields/success/gardner.htm
Note: EPHs for Ethanol, 2-phenoxy-; SVOCs for semi-volatile organic compounds.

4.2.1 Site Description

The brownfield site in Gardner, MA (Table 4-7, Figure 4-5, Figure 4-6) was a redevelopment of a former light manufacturing and welding shop. The city foreclosed the property in 2000 after it was vacant and had defaulted on its property tax for 5 years. The city secured the EPA Assessment fund of $47,000 to complete Phase two environmental assessment and identified the contaminants of EPHs, SVOCs, and lead. The Greater Gardner Community Development Corporation was awarded the Community Development Block Grant (CDBG) of $165,000 to redevelop the site as a three, single-family units of affordable housing in 2003. (Source: http://www.epa.gov/newengland/brownfields/success/gardner.htm)

The GIS map shows the location of the brownfield, single-family houses in a half-mile radius, streets, highways, and context (Figure 4-4). The photo and air photo show the redeveloped site and its context (Figure 4-5).

Figure 4-4: ArcGIS Map of Gardner, Half-Mile Radius of the Brownfield Site



Source: ArcGIS, U.S. StreetMap 9.1; Single-family addressed by Warren Group

Figure 4-5: Photograph and Air Photograph of the Brownfield Site in Gardner, MA

Source: EPA Region 1 Brownfield Success Stories and Google Earth 2006.

4.2.2 Data Set

The data set in Gardner contains 300 single-family housing transactions within a half-mile radius of the target brownfield site, with the sale years ranging from 1995 to 2006. The span covers pre-remediation and post redevelopment periods. Descriptive statistics for all the variables used in the model are shown in Table 4-8.

Table 4-8: Descriptive Statistics for the Brownfield in Gardner, MA

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
PRICE	300	51,000	274,900	120,549	47,134
DISTANCE	300	.046	.799	.473	.208
DIST_SQ	300	.002	.638	.267	.187
BATHROOMS	300	1.0	2.5	1.287	.4302
LOTSIZE	300	2.28	67.52	9.96	7.74
LOTSIZE2	300	5.21	4558.68	158.82	414.10
Living_area	300	.528	2.046	1.241	.273
LVGAREA2	300	.279	4.186	1.615	.694
AGE	300	0	167	73.76	25.891
SOLD_95	300	0	1	.04	.196
SOLD_96	300	0	1	.10	.296
SOLD_97	300	0	1	.09	.287
SOLD_98	300	0	1	.10	.301
SOLD_99	300	0	1	.11	.309
SOLD_00	300	0	1	.07	.261
SOLD_01	300	0	1	.06	.244
SOLD_02	300	0	1	.10	.296
SOLD_03	300	0	1	.10	.305
SOLD_04	300	0	1	.13	.333
SOLD_05	300	0	1	.09	.282
SOLD_06	300	0	1	.02	.128
style_anti	300	0	0	.00	.000
style_bnl	300	0	1	.17	.379
Style_cape	300	0	0	.00	.000
style_COLONIAL	300	0	1	.02	.128
sty_CONTEMP	300	0	0	.00	.000
style_FAMILY	300	0	1	.02	.140
style_MOBILE	300	0	0	.00	.000
style_rsrach	300	0	1	.01	.082
style_ranch	300	0	1	.15	.354
style_split	300	0	1	.01	.082
Valid N (listwise)	300				

Source: Author's calculations.

4.2.3 Data Analyses

Below are the major results of data analyses.

Price. To exclude non arm-length transactions, I exclude transactions with sale prices lower than $50,000. The scatterplot of price and distance for excluded observations show that these points are evenly distributed in different distances.

Distance. I select a half-mile radius to cover the impact region, taking into account the topography and another brownfield of 0.7 miles to the west. Housing within a half-mile should avoid these noise.

Living area, bathroom, and bedroom. The Pearson correlation between living area and bedroom is 0.52 and is significant at the 0.01 level. I regress ln(price) on living area and bedroom separately. Living area results in a more significant coefficient, therefore, I exclude the number of bedrooms.

Lot size and living area. Both lot size and living area variables exhibit a quadratic form. I therefore add the squares of lot size and age to the model.

4.2.4 Review of Regression Results

Through independent regressions and collinearity tests, I select the independent variables and their forms. I conduct regressions by using SPSS for the entire data set (Table 4-9). The regression model achieves a reasonably good result. The R square indicates that 75% of variation in ln(price) can be explained by all the independent variables listed in Table 4-9. Most independent variables are statistically significant at 95% confidence level.

Table 4-9: Regression Results for the Brownfield in Gardner, MA

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.908	.824	.809	.170

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	10.493	.171		61.487	.000
	DISTANCE	-.145	.051	-.077	-2.858	.005
	LOTSIZE	1.767E-02	.004	.350	4.720	.000
	LOTSIZE2	-2.91E-04	.000	-.308	-4.257	.000
	LIVING_A	1.079	.243	.753	4.434	.000
	LVGAREA2	-.320	.095	-.568	-3.354	.001
	AGE	-1.78E-03	.001	-.118	-2.895	.004
	SOLD_96	-6.49E-02	.060	-.049	-1.085	.279
	SOLD_97	-2.85E-02	.061	-.021	-.468	.640
	SOLD_98	4.142E-03	.059	.003	.070	.944
	SOLD_99	8.177E-02	.059	.065	1.397	.163
	SOLD_00	.209	.063	.140	3.333	.001
	SOLD_01	.475	.064	.297	7.439	.000
	SOLD_02	.496	.059	.376	8.348	.000
	SOLD_03	.673	.059	.525	11.484	.000
	SOLD_04	.809	.058	.690	14.069	.000
	SOLD_05	.910	.061	.657	15.019	.000
	SOLD_06	.833	.092	.274	9.087	.000
	STYLE_BN	4.928E-02	.034	.048	1.452	.148
	STYLE_CO	-2.45E-02	.082	-.008	-.298	.766
	STYLE_FA	9.984E-02	.073	.036	1.366	.173
	STYLE_RS	.165	.136	.034	1.210	.227
	STYLE_RA	5.668E-02	.043	.051	1.327	.186
	STYLE_SP	.109	.128	.023	.851	.396

a. Dependent Variable: LN_PRICE

Source: Author's calculations.

- The housing price appreciation from 1995 to 2006 is 83.3%. Housing prices appreciated greatly from 2002 to 2004.

- Houses of 10 year older have 1.78% of lower average prices.

- The coefficient for distance is -0.145 and significant at 95% confidence interval.

- Both living area and lot size present a quadratic form. The price premium increases as the living area/lot size grows, but decreases as it reaches a certain point (linear coefficient/(2*quadratic coefficient). A living area of 1,686 square feet (SF) has the largest price premium. The maximum price premium is realized for a lot size of 30,361 SF.

4.2.5 Comparison between Before and After Remediation Effects

I split the data set into two periods, 1996 to 2001 and 2002 to 2006, which cover the pre- and post-remediation periods. They consist of 183 and 119 cases respectively. The first data set captures the housing price before remediation, when brownfields should have negative price impacts. The second one reflects housing price changes in the post-redevelopment period. I conduct two additional regressions to (1) test the brownfield has negative housing price impact before remediation; (2) test the hypothesis that brownfield cleanup and redevelopment have significant positive impacts on housing prices; and (3) calculate the housing-price improvements due to brownfield redevelopment.

The R square results in Tables 4-10 and 4-11 show that the first formula explains 61.9% of variation in the natural logarithm of housing prices, and the second one explains 47.2% of variation. Both estimates are less precise than the regression for the whole data set, due to smaller sample sizes.

Table 4-10: Regression Results for the Brownfield in Gardner, MA, 1996 to 2001

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.812	.660	.619	.155

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	9.940	.260		38.250	.000
	DISTANCE	-.134	.064	-.114	-2.108	.037
	LOTSIZE	9.352E-03	.005	.249	1.785	.076
	LOTSIZE2	-7.66E-05	.000	-.086	-.640	.523
	LIVING_A	1.985	.392	2.101	5.068	.000
	LVGAREA2	-.665	.147	-1.840	-4.515	.000
	AGE	-2.37E-03	.001	-.246	-3.171	.002
	SOLD_97	4.664E-02	.044	.070	1.068	.287
	SOLD_98	6.503E-02	.042	.102	1.560	.121
	SOLD_99	.167	.041	.268	4.043	.000
	SOLD_00	.279	.045	.386	6.209	.000
	SOLD_01	.537	.048	.698	11.184	.000
	STYLE_BN	1.873E-02	.039	.030	.476	.635
	STYLE_CO	-1.19E-03	.076	-.001	-.016	.988
	STYLE_FA	.120	.112	.054	1.076	.284
	STYLE_RS	.133	.132	.059	1.004	.317
	STYLE_RA	.109	.054	.151	2.007	.047
	STYLE_SP	8.269E-02	.119	.037	.694	.489

a. Dependent Variable: LN_PRICE

Source: Author's calculations.

The price-distance gradient is negative before remediation, which means the residents' willingness to pay for living close to the site. It could be attributed to unidentified amenities in the neighborhood. The negative price impact of the brownfield cannot be verified.

Table 4-11: Regression Results for the Brownfield in Gardner, MA, 2002 to 2006

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.725	.526	.472	.183

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	11.136	.236		47.132	.000
	DISTANCE	-.181	.083	-.145	-2.192	.030
	LOTSIZE	2.450E-02	.007	.765	3.510	.001
	LOTSIZE2	-4.37E-04	.000	-.839	-3.918	.000
	LIVING_A	.644	.346	.722	1.861	.065
	LVGAREA2	-.141	.141	-.394	-1.003	.318
	AGE	-6.72E-04	.001	-.067	-.604	.547
	SOLD_03	.165	.049	.280	3.398	.001
	SOLD_04	.300	.046	.544	6.454	.000
	SOLD_05	.413	.051	.659	8.060	.000
	SOLD_06	.327	.091	.251	3.597	.000
	STYLE_BN	7.723E-02	.063	.111	1.226	.223
	STYLE_FA	2.710E-02	.101	.019	.268	.789
	STYLE_RA	4.356E-02	.074	.063	.590	.556

a. Dependent Variable: LN_PRICE

Source: Author’s calculations.

The gradient decreases from -0.134 to -0.181. Because the previous analyses cannot demonstrate the significant difference of two slopes, I merge two regressions by adding two groups of dummy variables. The redevelopment dummy is equal to 1 if the sales year is larger than 2001, and equal to 0 for the other cases. I multiply the distance variable by the redevelopment dummy to get the distance dummy (d_distance) and multiply structural variables by the redevelopment dummy to calculate structural dummies (e.g. d_lotsize, d_age). I perform a regression for the whole dataset. The distance dummy is 0.0252 but not significant (Table 4-12), which means the change of slope is not significant. Hence, further regression analysis shows that the brownfield redevelopment's impacts on housing price cannot be verified.

4.2.6 Conclusion

The local residents' benefits from brownfield redevelopment are not significant in the Gardner case. I cannot verify either of the hypothesis of brownfield redevelopment or disamenity of the brownfield, perhaps because of the noise of other unidentified amenities close to the site or local residents' unawareness of the pollution. Thus, the brownfield redevelopment's improvement on housing price is uncertain.

Table 4-12: Regression Results for the Brownfield in Gardner, MA with Distance and Structural Dummies

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.915	.837	.817	.167

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	9.992	.274		36.433	.000
	DISTANCE	-.181	.075	-.096	-2.409	.017
	LOTSIZE	2.450E-02	.006	.486	3.858	.000
	LOTSIZE2	-4.37E-04	.000	-.464	-4.306	.000
	LIVING_A	.644	.315	.449	2.045	.042
	LVGAREA2	-.141	.128	-.251	-1.102	.271
	AGE	-6.72E-04	.001	-.045	-.663	.508
	SOLD_96	-3.81E-02	.060	-.029	-.634	.527
	SOLD_97	1.002E-02	.062	.007	.163	.871
	SOLD_98	2.711E-02	.059	.021	.461	.645
	SOLD_99	.130	.059	.103	2.209	.028
	SOLD_00	.242	.063	.162	3.861	.000
	SOLD_01	.499	.063	.312	7.894	.000
	SOLD_02	1.144	.348	.867	3.283	.001
	SOLD_03	1.309	.348	1.022	3.766	.000
	SOLD_04	1.444	.348	1.232	4.153	.000
	SOLD_05	1.557	.348	1.124	4.473	.000
	SOLD_06	1.471	.356	.483	4.135	.000
	STYLE_BN	7.723E-02	.057	.075	1.348	.179
	STYLE_FA	2.710E-02	.092	.010	.294	.769
	STYLE_RA	4.356E-02	.067	.040	.648	.517
	d_distance	2.524E-02	.101	.019	.250	.803
	d_lotsize	-1.75E-02	.008	-.346	-2.135	.034
	D_LOT2	4.144E-04	.000	.296	2.777	.006
	D_LVGA	1.304	.517	2.196	2.520	.012
	D_LVGA2	-.505	.201	-1.262	-2.515	.012
	D_AGE	-1.39E-03	.001	-.144	-1.090	.277
	D_BN	-4.64E-02	.071	-.037	-.654	.514
	D_CO	1.175E-02	.082	.004	.143	.886
	D_FA	9.118E-02	.152	.019	.600	.549
	D_RS	.174	.141	.036	1.237	.217
	D_RA	8.940E-02	.088	.062	1.014	.312
	D_SP	.111	.128	.023	.870	.385

a. Dependent Variable: LN_PRICE

Source: Author's calculations.

4.3 Case 3: Lynn, MA

Table 4-13: Highlights of Empire Laundry Site in Lynn, MA

Redevelopment End Use	single-family affordable housing
Site Location	33-35 Myrtle St, Lynn, MA 01905
Size	36,000 SF
Pollution Types	Solvents
Abandon Date	1993
Remediation Start Date	2000
Remediation Finish Date	2002
Total Government Funds	$355,000
No. of Transaction Data Available	855

Source: EPA Region One Brownfield Website.
http://www.epa.gov/NE/brownfields/success/lynn.htm

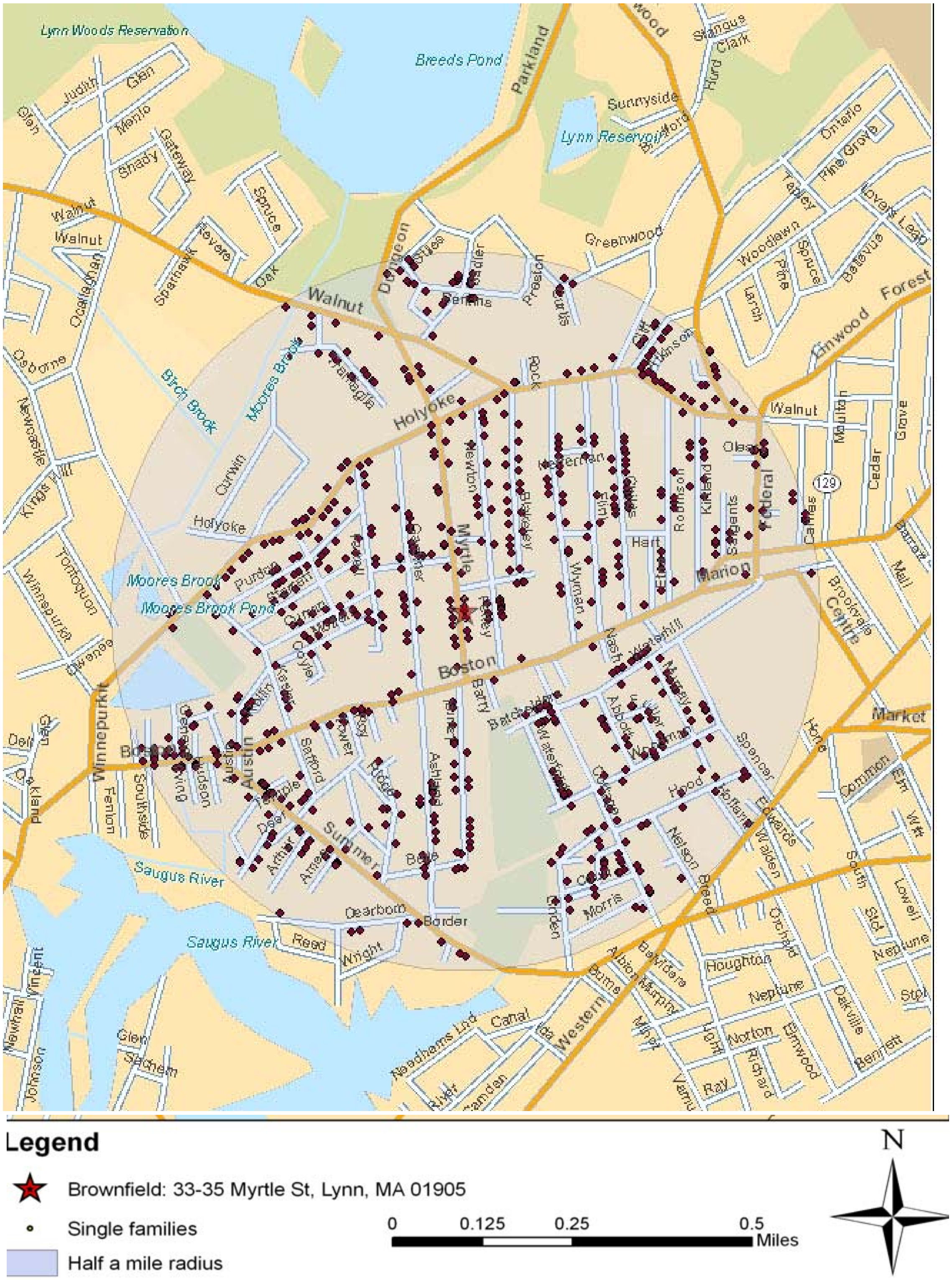
4.3.1 Site Description

The brownfield site in Lynn, MA (Table 4-13) was a redevelopment of a formal commercial laundry facility. The laundry had been operating from the early 1990's until 1993. The city foreclosed the property in 1996 after it was abandoned in 1993. The city was awarded a $20,000 grant from EPA to perform an environmental assessment in 1998 and identified hazardous materials, such as solvents. In 1999, the city secured $420,000 from Brownfields Cleanup Revolving Loan Fund and a $100,000 pilot grant from the EPA to cleanup the site. The cleanup was completed in 2002 with the removal of 2,423 pounds of solid waste, 324 gallons of liquid waste, and 163 bags of asbestos-tainted materials.

(Source: EPA Region 1 Brownfield website:
http://www.epa.gov/NE/brownfields/success/lynn.htm)

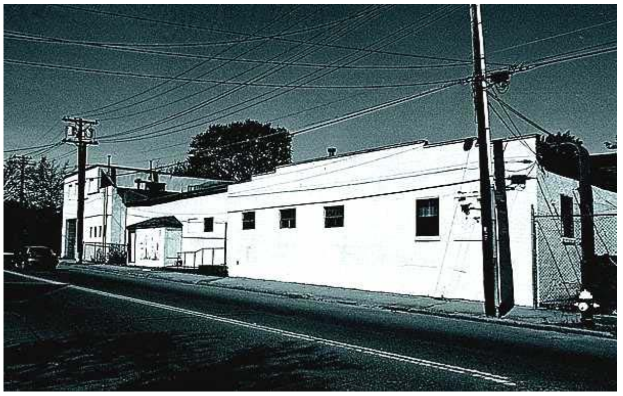
The following map shows the location of the brownfield and single-family houses in a half-mile (Figure 4-6). The photo and air photo show the site before and after remediation and its neighborhood (Figure 4-7).

Figure 4-6: ArcGIS Map of Lynn, Half-Mile Radius of the Brownfield Site



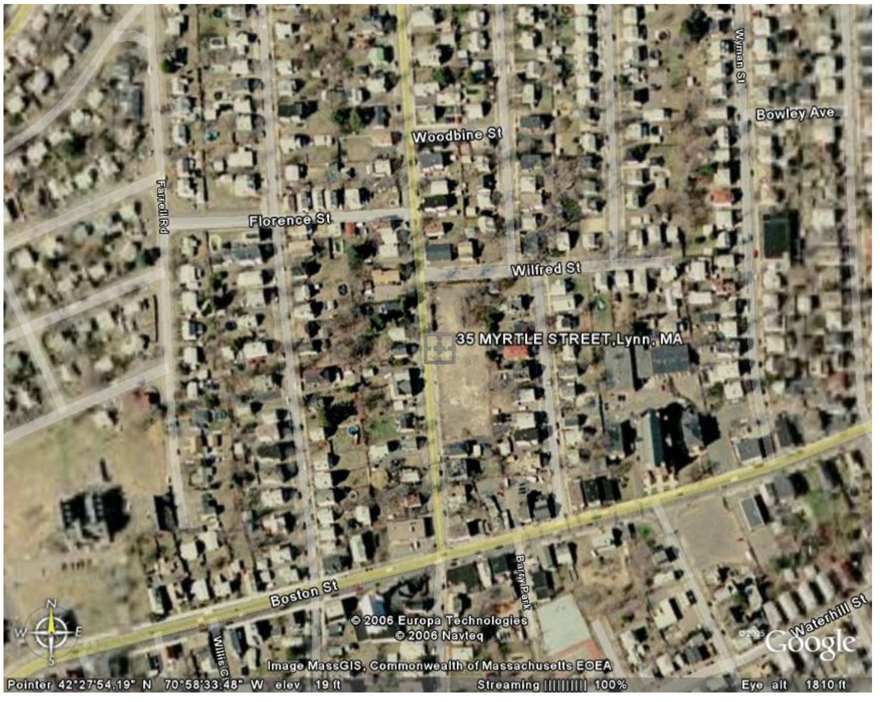
Source: ArcGIS, U.S. StreetMap 9.1; Single-family addressed by Warren Group

Figure 4-7: Photograph and Air Photograph of the Empire Laundry Site in Lynn, MA



Before Remediation

After Remediation



Context Photo

Source: EPA Region 1 Brownfield Success Stories and Google Earth 2006.

4.3.2 Data Set

The Lynn, MA site contains 855 single-family housing transactions within a half-mile radius of the target brownfield site, with the sale years ranging from 1994 to 2006. The span covers pre-remediation and post-redevelopment periods. Descriptive statistics for all the variables used in the model are shown in Table 4-14.

Table 4-14: Descriptive Statistics for the Brownfield in Lynn, MA

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
PRICE	855	51,000	475,000	166,589	79,057
DISTANCE	855	.009	.800	.494	.193
DIST_SQ	855	.000	.639	.281	.180
DISTGE	855	.257	1.761	1.016	.354
LOTSIZE	855	.871	29.621	5.024	2.329
LOTSIZE2	855	.759	877.404	30.655	42.250
Living_area	855	.595	3.456	1.276	.312
Lvg_area2	855	.354	11.944	1.724	.951
AGE	855	0	248	82.66	30.289
SOLD_94	855	0	1	.06	.235
SOLD_95	855	0	1	.06	.241
SOLD_96	855	0	1	.08	.267
SOLD_97	855	0	1	.08	.278
SOLD_98	855	0	1	.08	.267
SOLD_99	855	0	1	.09	.291
SOLD_00	855	0	1	.08	.267
SOLD_01	855	0	1	.08	.274
SOLD_02	855	0	1	.08	.269
SOLD_03	855	0	1	.10	.296
SOLD_04	855	0	1	.10	.301
SOLD_05	855	0	1	.09	.291
SOLD_06	855	0	1	.02	.136
STY_BNGL	855	0	1	.02	.136
style_cape	855	0	1	.17	.380
style_colonial	855	0	1	.19	.392
sty_contemp	855	0	1	.00	.034
STY_MUL	855	0	0	.00	.000
sty_raise	855	0	1	.00	.068
sty_ranch	855	0	1	.07	.258
STY_SPL	855	0	0	.00	.000
STY_SPE	855	0	1	.01	.096
STY_TWO	855	0	1	.01	.090
style_victorian	855	0	0	.00	.000
Valid N (listwise)	855				

Source: Author’s calculations.

4.3.3 Data Analyses

Below are the major results of data analyses.

Price. To exclude non arm-length transactions, I exclude transactions with sale prices lower than $50,000. The exclusion does not skew the price and distance relationship.

Distance. I select a half-mile radius to cover the impact region, considering the topography in the North and South. Housing within a half-mile should avoid this noise. In addition, the GE (General Electric) Industrial Complex on the South may have a much larger impact on housing prices than the small brownfield. I add the distance to GE site into the regression to reflect its impact.

Living area, bathroom, and bedroom. The Pearson correlation between living area and bedroom and bathroom is 0.473 and 0.416 and both correlation coefficients are significant at the 0.01 level. Based on regression analyses, I select only the living-area variable.

Lot size, living area, and age. I perform separate regressions on lot size, living area, age. Lot size and living area exhibit quadratic forms, while age presents a linear form.

4.3.4 Review of Regression Results

The regression model achieves a reasonably good result. The R square indicates that 83.3% of variation in ln(price) can be explained by all the independent variables listed in Table 4-15. Most independent variables are statistically significant at 95% confidence level.

Table 4-15: Regression Results for the Brownfield in Lynn, MA

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.916	.838	.833	.201

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	10.633	.109		97.258	.000
	DISTANCE	.246	.168	.096	1.465	.143
	DIST_SQ	-.228	.181	-.084	-1.259	.209
	DISTGE	.134	.023	.097	5.885	.000
	LOTSIZE	2.495E-02	.007	.118	3.440	.001
	LOTSIZE2	-7.05E-04	.000	-.061	-1.899	.058
	Living_area	.590	.127	.374	4.637	.000
	Lvg_area2	-.119	.043	-.231	-2.782	.006
	AGE	-1.77E-03	.000	-.109	-5.045	.000
	SOLD_95	-6.37E-02	.040	-.031	-1.596	.111
	SOLD_96	4.257E-02	.038	.023	1.117	.264
	SOLD_97	.114	.037	.064	3.051	.002
	SOLD_98	.243	.038	.132	6.392	.000
	SOLD_99	.360	.036	.214	9.872	.000
	SOLD_00	.524	.038	.285	13.799	.000
	SOLD_01	.721	.037	.403	19.237	.000
	SOLD_02	.928	.038	.507	24.501	.000
	SOLD_03	1.011	.036	.609	27.876	.000
	SOLD_04	1.111	.036	.680	30.665	.000
	SOLD_05	1.180	.037	.700	32.275	.000
	SOLD_06	1.069	.058	.295	18.422	.000
	style_cape	1.516E-02	.026	.012	.582	.560
	style_colonial	-1.35E-02	.022	-.011	-.624	.533
	sty_contemp	.104	.270	.007	.386	.700
	sty_raise	2.412E-02	.105	.003	.229	.819
	sty_ranch	1.984E-02	.035	.010	.573	.567
	STY_SPE	7.808E-02	.078	.015	1.006	.315
	STY_TWO	1.791E-02	.080	.003	.224	.823

a. Dependent Variable: LN_PRICE

Source: Author's calculations.

- The housing-price appreciation from 1994 to 2006 is 106.9%. Housing prices appreciated greatly during 1997 to 2004.

- A living area of 2,479 SF has the largest price premium, while the maximum price premium is realized at a Lot size of 17,695 SF.

- Houses that are 10 years older have a 1.8% of lower average prices.

- The styles do not have significant price premiums.

- The coefficient for distance to the brownfield is positive but not significant, while distance to the GE Industrial Complex exhibits significant price impacts. One thousand meters away from the GE site provides a 13.4% price premium.

4.3.5 Comparison Between Before and After Remediation Effects

I split the data set into two parts, i.e., 1994 to 2001 and 2002 to 2006, which covers the pre- and post-remediation periods. They consist of 522 and 324 cases, respectively. I perform regressions on both of the two sub-datasets by using the same variables for the whole sample. The first data set captures the housing price before remediation, when brownfields should have negative price impacts. The second one reflects housing price changes in the post-redevelopment period.

The R square results in Tables 4-16 and 4-17 show that the first regression explains 63.3% of variation in the natural logarithm of housing prices, and the second one explains 57.9% of variation. Both estimates are less precise than the regression for the whole data set, due to smaller sample sizes.

Table 4-16: Regression Results for the Brownfield in Lynn, MA, 1994 to 2001 (Pre-Remediation)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.805	.649	.633	.210

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	10.574	.136		77.801	.000
	DISTANCE	7.902E-02	.053	.042	1.489	.137
	DISTGE	.109	.031	.111	3.559	.000
	LOTSIZE	3.347E-02	.009	.234	3.642	.000
	LOTSIZE2	-1.06E-03	.000	-.150	-2.491	.013
	LIVING_A	.779	.160	.674	4.854	.000
	LVGA2	-.186	.053	-.476	-3.497	.001
	AGE	-2.42E-03	.000	-.209	-4.892	.000
	SOLD_95	-7.00E-02	.042	-.061	-1.668	.096
	SOLD_96	4.194E-02	.040	.040	1.047	.295
	SOLD_97	.108	.039	.107	2.749	.006
	SOLD_98	.248	.040	.237	6.188	.000
	SOLD_99	.366	.038	.380	9.517	.000
	SOLD_00	.534	.040	.511	13.346	.000
	SOLD_01	.728	.040	.715	18.393	.000
	STY_BNGL	1.769E-02	.073	.007	.242	.809
	STYLE_CA	-3.42E-03	.036	-.004	-.094	.925
	STYLE_CO	-2.33E-02	.029	-.026	-.800	.424
	STY_RAIS	8.022E-02	.155	.014	.517	.605
	STY_RANC	1.689E-02	.046	.013	.365	.715
	STY_SPE	2.806E-02	.095	.009	.294	.769
	STY_TWO	5.338E-02	.109	.013	.489	.625

a. Dependent Variable: LN_PRICE

Source: Author's calculations.

Table 4-17: Regression Results for the Brownfield in Lynn, MA, 2002 to 2006 (Post Remediation)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.777	.604	.579	.136

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	11.794	.127		92.683	.000
	DISTANCE	-2.92E-02	.041	-.028	-.712	.477
	DISTGE	.135	.025	.227	5.340	.000
	LOTSIZE	3.379E-02	.013	.349	2.557	.011
	LOTSIZE2	-1.52E-03	.001	-.211	-1.589	.113
	LIVING_A	.172	.171	.269	1.008	.314
	LVGA2	2.803E-02	.059	.139	.478	.633
	AGE	-5.36E-04	.000	-.079	-1.463	.144
	SOLD_03	7.909E-02	.023	.164	3.419	.001
	SOLD_04	.172	.023	.360	7.462	.000
	SOLD_05	.238	.023	.488	10.222	.000
	SOLD_06	.169	.039	.169	4.279	.000
	STY_BNGL	-.103	.054	-.072	-1.907	.057
	STYLE_CA	4.565E-02	.026	.086	1.734	.084
	STYLE_CO	-2.23E-03	.024	-.004	-.093	.926
	STY_CONT	-.529	.280	-.140	-1.887	.060
	STY_RAIS	-1.28E-02	.102	-.005	-.125	.901
	STY_RANC	.104	.042	.110	2.493	.013
	STY_SPE	.154	.105	.057	1.464	.144
	STY_TWO	.310	.120	.115	2.584	.010

a. Dependent Variable: LN_PRICE

Source: Author's calculations.

The price-distance gradient before remediation is positive but not significant. The brownfield' negative price impact cannot be verified. One possible reason is that the GE site has larger impacts and the distance to the GE site cannot capture the entire price impacts precisely. Another possible reason could be that other major development or disamenities in the radius are neglected in the model.

The gradient decreases from 0.079 to -0.0292 after remediation. Brownfield redevelopment could lower the gradient, i.e., improving housing prices. However, I cannot determine whether the difference is significant. I merge two regressions by adding two groups of dummy variables. The redevelopment dummy is equal to 1 if the sales year is larger than 2001, and equal to 0 for the other cases. I multiply the distance variable by the redevelopment dummy to get the distance dummy (d_distance) and multiply structural variables by the redevelopment dummy to calculate structural dummies (e.g. d_lotsize, d_age). I perform a regression for the whole dataset. The distance dummy is -0.103 but not significant (Table 4-18), which means the positive price impact is not significant. Hence, further regression analysis shows that the brownfield redevelopment's positive impacts on housing price cannot be verified.

Table 4-18: Regression Results for the Brownfield in Lynn, MA with Distance and

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.918	.842	.834	.200

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	10.574	.129		81.724	.000
	DISTANCE	7.902E-02	.051	.031	1.564	.118
	DISTGE	.109	.029	.078	3.738	.000
	d_distance	-.103	.078	-.057	-1.327	.185
	D_GE	6.037E-02	.047	.066	1.291	.197
	d_lotsize	-3.09E-02	.021	-.172	-1.496	.135
	D_LOT2	1.756E-03	.001	.082	1.266	.206
	D_LIVA	-.669	.292	-.895	-2.294	.022
	D_LIVA2	.241	.099	.525	2.424	.016
	D_AGE	1.502E-03	.001	.140	2.108	.035
	D_BNGL	-.132	.106	-.024	-1.254	.210
	D_CA	5.042E-02	.052	.027	.972	.332
	D_CO	1.217E-02	.045	.007	.272	.786
	D_RAIS	-.118	.211	-.012	-.558	.577
	D_RANC	-1.37E-02	.073	-.004	-.186	.852
	D_SPE	.118	.179	.012	.660	.510
	D_TWO	-.123	.170	-.015	-.722	.471
	LOTSIZE	3.347E-02	.009	.159	3.825	.000
	LOTSIZE2	-1.06E-03	.000	-.092	-2.616	.009
	LIVING_A	.779	.153	.494	5.099	.000
	LVGA2	-.186	.051	-.360	-3.673	.000
	AGE	-2.42E-03	.000	-.149	-5.139	.000
	SOLD_95	-7.00E-02	.040	-.034	-1.752	.080
	SOLD_96	4.194E-02	.038	.023	1.100	.272
	SOLD_97	.108	.037	.061	2.888	.004
	SOLD_98	.248	.038	.134	6.500	.000
	SOLD_99	.366	.037	.217	9.996	.000
	SOLD_00	.534	.038	.290	14.019	.000
	SOLD_01	.728	.038	.406	19.321	.000
	SOLD_02	1.328	.225	.726	5.909	.000
	SOLD_03	1.417	.223	.854	6.358	.000
	SOLD_04	1.501	.222	.919	6.775	.000
	SOLD_05	1.577	.222	.935	7.092	.000
	SOLD_06	1.472	.228	.406	6.467	.000
	STY_BNGL	1.769E-02	.070	.005	.254	.800
	STYLE_CA	-3.42E-03	.035	-.003	-.098	.922
	STYLE_CO	-2.33E-02	.028	-.019	-.841	.401
	STY_CONT	-.632	.410	-.044	-1.543	.123
	STY_RAIS	8.022E-02	.148	.011	.543	.587
	STY_RANC	1.689E-02	.044	.009	.383	.702
	STY_SPE	2.806E-02	.091	.005	.309	.758
	STY_TWO	5.338E-02	.104	.010	.513	.608

a. Dependent Variable: LN_PRICE

4.3.6 Conclusion

The local residents' benefits from brownfield redevelopment are not significant in the Lynn case. This brownfield project's public funds cannot be justified by its public benefits generated, at least when considering only the local residents' benefits. I cannot verify either the hypothesis of brownfield redevelopment, nor can I identify the disamenity of the brownfield, which could be attributed to the noise of the GE site and local residents' unawareness of the pollution. Local residents may not realize the actual risk posed by the brownfield site, given the nature of the site (a former laundry). The brownfield redevelopment's impact on housing prices is positive but not significant.

4.4. Major Findings from Case Studies

I perform hedonic-model analyses and social benefits and costs analyses on three brownfield redevelopment cases in Massachusetts. The hypothesis of this study is only verified in the case in Brockton, where the NPSV is positive and IRR is larger than other government projects.

The level of negative impacts of brownfields varies

As indicated from the three case studies, the negative housing price impacts of the brownfield in Lynn are not significant and the brownfield in Brockton exhibits a maximum of 10% negative price impact, while the brownfield price impact in Gardner is hidden by other impacts. Although I use "brownfield" as a single name for polluted properties, the severity of pollution and the local residents' awareness of pollution may vary. Those are two of many reasons why price impacts vary.

The benefits of redevelopment are smaller than expected

Only one of the three cases shows a significant positive price impact of brownfield redevelopment. Although brownfield cleanup and redevelopment generate benefits to local residents, the housing market may not reflect the positive impacts. Compared to other impacts (e.g. the opening of a shopping mall), brownfields' impacts are less pronounced in many cases.

The social return can be very high

As shown in the Brockton case, the social benefits are much larger than the public funds invested. Brownfield funds serves as a catalyst for private investment. One word of caution is that I cannot verify if the funds are allocated optimally in the Brockton case, because I do not have the private NPV information. Private investors may have positive private NPV and public funds may not be necessary for this remediation and redevelopment.

4.5 Cautions when Interpreting Results

Readers should be cautious when interpreting and applying the results. The case studies employ social benefit-cost analyses and the benefits are based on the hedonic method. I have made many assumptions and approximations.

Selection Bias

The three cases are selected from the successful redevelopment projects in Massachusetts funded by EPA. They probably do not represent the general situations of brownfield redevelopment in the United States.

Partial Consideration of Public Benefits

As discussed in Chapter 3, I only consider local residents' benefits. The estimated benefits are lower than total public benefits. Therefore, I can only verify that a project has a positive NPSV, but I cannot verify that a project's NPSV is negative, because of unconsidered benefits.

Perceived Benefits and Real Benefits

I realize that there are two types of benefits, i.e., perceived benefits and real benefits. A hedonic model only reflects the perceived risks/benefits, which may be different from the real risks/benefits. Real benefits come from the reduced health risks, green-space saving, efficient use of infrastructure, etc. Perceived benefits come from the reduction of perceived risks and the disamenity. McClelland et al. (1990) showed that the risks perceived by residents are different from real risk measured by scientific analysis. For example, the potential environmental risks in the Lynn brownfield are severe. However, the perceived risks could be low, given the nature of the site, a former commercial laundry.

The Composition of Housing Price Appreciation

For this study, I measure the brownfield redevelopment's impact on housing price by using hedonic models to aggregate the three effects for neighborhood residents: (1) the local residents' benefits of brownfield remediation and redevelopment, (2) economic benefits of living close to the redeveloped project, and (3) negative costs of the redeveloped use (e.g. traffic, noise, and crime). I assume that the aggregate values of these benefits and costs are close to local residents' benefits from brownfield cleanup and redevelopment.

Net or Transfer of Benefits

The housing price appreciation consists of the transfer of market demand and the net benefits from brownfield redevelopment. The improvement of housing price in an area after remediation may reduce the price or demand of housing in another area. I was not able to differentiate the differences of net benefits or a transfer of benefits. A further study using a general equilibrium model is needed to fit in the gap.

The Nature of Redevelopment

I notice that both of the two cases with insignificant price impact have end uses of affordable housing. Affordable housing has lower-than-market rate prices, which may lower the neighborhood housing prices. Both of these factors can decrease the significance of housing price appreciation due to brownfield redevelopment.

The Short Period of Post-Remediation

The three redevelopments were completed less than four year ago. The short time window may not allow the effect of cleanup and redevelopment to be reflected in housing market.

Development Dynamics

One of the major assumptions of hedonic models is that other amenities and disamenities do not change between pre- and post-remediation periods so that we can cancel out their effects by calculating the difference of two distance slopes. If the development activities are active during the observation period, they may make it difficult to interpret the regression results.

Chapter 5

Conclusion

In this chapter, I first highlight the major findings from this study. Then, I discuss the limitations of current methodologies and the directions of future improvements. Finally, I propose policy recommendations on how to improve the efficiency of brownfield policies.

In this study, I create a quantitative framework for allocating brownfield funds and apply social benefit-cost analysis to evaluate the efficiency of current financing programs by examining three brownfield redevelopment cases in Massachusetts. I hope that this new perspective brought by this empirical study will give some thoughts for regulators and researchers.

5.1 The Major Findings of This Study

In this study, I propose the flow chart for an optimal brownfield-funding decision. I test the hypothesis that some brownfield funds are allocated to projects with negative net present social values (NPSVs), i.e., suboptimal. The social costs are brownfield funds allocated to a project. I only consider local residents' benefits, one of the three public benefits from brownfield redevelopment. I use hedonic models to measure indirectly local residents' benefits. Among three brownfield cases, I verify that only one of them brownfield funds has a positive NPSV, though I cannot prove if public funds are allocated optimally in this case, due to lack of private NPV information.

5.1.1 The Ideal Situation for an Optimal Brownfield Funding Decision

Ideally, the brownfield funds can be allocated, according to the flow chart proposed in Chapter 3. Projects that have positive or zero private net present values (NPVs) are not eligible for funding application. Projects with negative private NPVs but positive net present social values (NPSV) can enter the pool of funding consideration. If funds are limited, the priorities are given to the projects with the largest NPSVs.

5.1.2 Measurement of Public Benefits and Costs

The social costs or investments for brownfield redevelopment are relatively easy to obtain. Basically, they are public funds from different sources, such as EPA, HUD, states, and cities. I ignore the indirect costs, such as infrastructure, traffic, noises, and new pollution from a redeveloped use, of a redevelopment for the society are ignored in this study.

I categorize public benefits of brownfield redevelopment into three parts based on the types of recipients: (1) local residents' willingness to pay for environmental, health, and aesthetic values; (2) local businesses' willingness to pay for increased engagement of customers and employees; (3) the nationals' willingness to pay for environmental improvement, e.g. green space saving. I can measure the first two types indirectly through hedonic models on residential properties and commercial properties. Other studies measure the local residents' benefits directly, i.e., translate environmental risks of brownfields into the number of cancer or other diseases cases averted in the impact region and then assign monetary values to derive the benefits of brownfield redevelopment (Hamilton and Viscusi 1999). I could measure the last part by using contingent valuation, which measures the public's willingness-to-pay for non-market goods through surveys and questionnaires. Due to the access of data and time limitation, I only focus on the first type of public benefits, i.e., local residents' benefits by using hedonic-model analyses. It is evident that the benefits I estimate would be lower than the full public benefits. However, the other two types of benefits are more controversial and their boundaries are more blurry.

5.1.3 Background Noise for the Impacts of Brownfields and Brownfield Redevelopment

As shown in the three case studies, brownfields' negative impacts are not pronounced as expected, which may be attributed to several reasons. First, housing price impacts reflect perceived risks of brownfields. Due to the varying level of environmental awareness, housing market may not reflect the real environmental risks. The environmental awareness varies in different groups of residents and in different types of pollution. Second, the housing prices in the neighborhood are subject to the impacts of other development. These impacts may be more pronounced than brownfield redevelopment. Finally, unlike other hazardous sites, brownfields often have less pollution and publicity. The price impact of brownfields is relatively small compared to other impacts. Therefore, it is easy to be interfered with and hidden by other impacts.

5.2 Issues in the Methodologies and Future Improvements

I realize the limitation in the methodologies for measuring benefits and costs and future work that could be done to improve this research.

5.2.1 The Limitation of Hedonic Model in Evaluating Social Benefits

The main limitation of using the hedonic model in evaluating social benefits of brownfield redevelopment is that it can be used only for ex-post research, because it builds on transactions data. Analysts cannot project the potential benefits from a proposal based on hedonic analysis. Its application is limited and cannot be applied to the optimal funding decision as mentioned in Chapter 3. Further studies can build on more representative case studies to develop a rule-of-thumb method to determine public benefits.

Analysts can use the hedonic model to measure the perceived risks/benefits, which are different from real risks/benefits. Due to the varying level of environmental awareness, the perceived risks can be greatly different from real risks. In order to fulfill the optimal funding decisions, future studies should explore ways to calculate the real benefits or adjust perceived benefits.

The hedonic model is dependent on a series of structural and neighborhood characteristics variables. The model, in many cases, is sensitive to missing values/variables and recording errors. Data availability and accuracy are always problems in the real world. If these problems are not handled appropriately, the model results may be skewed.

The model is sensitive to other development and amenity or disamenity factors in the region, such as metro stations, other brownfields, and industrial parks. It is very difficult to differentiate the distance-to-brownfield effect from that to other sites, given the complexity of development dynamics. By failing to consider other impacts, researchers may end up with a misleading conclusion.

Further studies can create distance-year dummy for each year and test the significance, thus identifying the vintage year for price-distance effect change. I did not include it, because the purpose of this study is to verify whether the cleanup and redevelopment have produced positive price impact and to quantify the benefits.

5.2.2 Difficulty in Tracking Public Funds and Social Costs

Brownfields are often located in low-income or distressed area, where they are eligible for other government subsidies. It is difficult to differentiate the public funds for brownfield redevelopment efforts from those for other efforts. For example, developers often tap low-income housing tax credits, zoning variance, and subsidized financing. Cities often offer zoning relief, which are difficult to quantify the costs.

5.2.3 Difficulty in Measuring the Full Public Benefits

Many fewer transaction data are available for commercial properties than for single-family houses, which make it difficult to measure local businesses' benefits from brownfield redevelopment. Contingent valuation (CV) is available to measure directly the willingness-to-pay for environmental goods of the society, but it requires a greater effort and more financial resources than the hedonic model. Although analysts often use CV for evaluating public benefits of large projects, most brownfield funds are too small to justify CV approach.

All in all, it is difficult to realize the optimal funding decision based on the flow chart I proposed, due to measurement issues. The major issue is to quantify all the public benefits accurately and beforehand. A rule-of-thumb method in evaluating public benefits quickly may be useful in accomplishing the optimization of brownfield funding allocation.

5.3 Policy Recommendation

Building on the theoretical analyses and case studies in Massachusetts, I propose the following recommendations for brownfield policies.

5.3.1 Optimize Brownfield Funding

Brownfield financing programs have given an impetus to brownfield redevelopment through financial assistance. However, the brownfield funding is limited. There is much room for improvement on current financing programs so as to maximize the return of the public financial resources (see Chapter 2).

Cut back unnecessary funding

As discussed in Chapter 3, some brownfield funding receivers would have redeveloped their projects even without brownfield funding. By requiring developers who apply for funding to provide Proforma information, the government can evaluate the needs and priority of funding for the project and allocate the funding based on the framework proposed in Chapter 3. For those positive private NPV projects, the government should not grant funding. Generally speaking, for a brownfield of a larger parcel in a prime location, the remediation costs can be easily absorbed by the project.

Prioritize funding allocation

Funding cannot meet the needs of every redevelopment project, which contributes to positive social returns. Currently federal funds are allocated to local agencies based on their proposals, and then local agencies distribute the financial resources to individual brownfield projects. I could not find a consistent and quantitative way to evaluate the funding application and allocate the financial resource. By adopting the principle of maximization of social returns, I propose a more straightforward and consistent method of allocating the funds.

Optimize the Timing

It is worth exploring when a redevelopment should be done from the social perspective.

Some redevelopment projects do not have positive NPSV, but may become positive in the future. Three factors can change NPSVs. (1) Environmental goods can be seen as a kind of luxury goods. With the improvement of living standards, the willingness-to-pay for environmental goods will increase. (2) The remediation costs may be reduced by the technological innovation. (3) From the developers' point of views, the current market may not support the redevelopment, but the project would be feasible if the market improves. To optimize the timing, the government should have a strategic view of brownfield policy by projecting the market environment (rents, vacancies, construction costs, etc.), technology change, and people's preferences. It is evident that it makes no sense to fund a redevelopment project in a poor location with few health and environmental impacts, from the pure NPSV perspective.

Integrate and Streamline Brownfield Financing Programs

Current brownfield financing programs are scattered in different agencies. The amount of each funding is relatively small. In many cases, developers would rather not to apply for these funds, because of the time and efforts to make an application. These funding programs would become more attractive for developers if they are integrated and streamlined. First, the amount of each award would be larger. Second, the transaction costs for developers and management costs for government could be minimized. Finally, it would be easier for developers to apply to one or two agencies.

Site Assessment Funds Focus on Marginal Sites

Developers are ingrained with high perceived risks and would not touch brownfield sites, especially for marginal sites, because marginal sites are in locations of week demand and/or have severe perceived environmental problems. Although some marginal sites may be economically feasible after environmental assessment, developers tend to turn away from these deals first. Site assessment funds should be focused on marginal sites, rather than sites in prime locations, which developers will definitely redevelop.

5.3.2 Proliferate Non-financial Incentives

Besides financial barriers, liability concerns and other non-economic factors are impediments for brownfield redevelopment. Removing the uncertainties, such as liability mitigation, will achieve similar results as financial incentives, but does not require financial resources.

Liability Mitigation

Although developers can shield themselves from further action from states through no further action (NFA) and covenant not to sue (CNTS), states reserve the rights to re-open a case if new contamination is discovered. Furthermore, citizens can sue developers in the future. The uncertainties increase the risks of brownfield projects and, in turn, the costs of capital. It is very important to design a legal structure to protect brownfield developers from the litigation for the pollution for which they are not responsible.

Encourage Positive Innovation in Brownfield Redevelopment

The government should encourage those innovations in brownfield redevelopment that reduce the risks and accelerated the redevelopment process. Insurers have developed innovative insurance products to reduce the risks of brownfield projects, such as coverage for cleanup costs overrun, costs to remediate undiscovered contaminants, liabilities due to incomplete or improper remediation and other risks. For small projects, cities sometimes provide a guarantee so as to lower the lending costs. Venture capital firms, such as Cherokee Investment and Brownfield Capital, have recently emerged in the brownfield redevelopment industry. As an investment from the private sector, it reduces the risk exposure of governments and increases the financial resources for brownfield redevelopment.

REFERENCES

Alberini, Anna, Heberle, Lauren, Meyer, Peter, and Wernstedt, Kris. 2004. The Brownfields Phenomenon: Much Ado about Something or the Timing of the Shrewd? Washington, DC: Resources For the Future.

Bartsch, Charles, and Wells, Barbara. 2003. Financing Strategies for Brownfield Cleanup and Redevelopment. Washington DC: Northeast-Midwest Institute.

Battle, Sophia. 2003. Public-Private Partnerships in Brownfields Redevelopment: Chicago, Illinois and Vienna, Austria. NEURUS - Network of European and US Regional and Urban Studies.

Brealey, Richard A. and Stewart C. Myers. 2006. Principles of corporate finance. New York, NY: McGraw-Hill/Irwin.

Coase, Ronald H. 1960. “The Problem of Social Cost.” The Journal of Law & *Economics*, Vol. 3, No. 1, pp. 1-44.

Elena Sophia Francisco. 2002. The Effect of Contemporary Supermarket Formats (Superstores) on Surrounding Residential Property Values. MIT Master Thesis.

EPA Region 1 Brownfield Websites
http://www.epa.gov/NE/brownfields/

EPA Success Stories: Gardner. 2002. “60 West Lynde Street and 30 Wickman Drive, Gardner, MA”
http://www.epa.gov/newengland/brownfields/success/gardner.htm

EPA Success Stories: Lynn. 2002. “Myrtle Street Brownfields Redevelopment”
http://www.epa.gov/region01/brownfields/success/lynn.htm

EPA Success Stories: Brockton. 2004. “Former Brockton Shoe Factory Lands on its Feet”
http://www.epa.gov/newengland/brownfields/success/brockton_tba.htm

ESRI. 2005. StreetMap USA 9.1.

Farber, Stephen. 1998. “Undesirable Facilities and Property Values: A Summary of Empirical Studies.” *Ecological Economics*, Vol. 24, No.1, pp.1-14.

Google. 2006. Google Earth 2006.

Greenberg, Michael, and Lewis, Jane. 2000. “Brownfields Redevelopment, Preferences and Public Involvement: A case Study of an ethnically mixed Neighborhood," Urban Studies, Vol. 37, No.13, pp. 2501-2514.

Hamilton, James T., and Viscusi, W. Kip. 1999. "How Costly Is 'Clean'? An Analysis of the Benefits and Costs of Superfund Site Remediations." *Journal of Policy Analysis and Management*, Vol. 18, No. 1, pp. 2-27.

Kiel, Katherine, and Zabel, Jeffery. 2001. "Estimating the Economic Benefits of Cleaning Up Superfund Sites: The Case of Woburn, Massachusetts." *Journal of Real Estate Finance and Economics*, Vol. 22, No. 2-3, pp.163-184.

Lange, Deborah, and McNeil, Sue. 2004. "Clean It and They Will Come? Defining Successful Brownfield Development." *Journal of Urban Planning and Development*, Vol. 130, No. 2, pp.101-108.

Lange, Deborah, and McNeil, Sue. 2004. "Brownfield Development: Tools for Stewardship." *Journal of Urban Planning and Development*, Vol. 130, No. 2, pp. 109-116.

Lomas-Jylhä, Tammy, and Coutinho, Wayne. 2005. Ontario Brownfields Toolbox: 10 Key Elements of A Brownfields Redevelopment Strategy for Ontario Municipalities. Canada: aboutREMEDIATION, 2005.

McClelland, Gary H., Schulze, William D., and Hurd, Brian. 1990. "The Effect of Risk Beliefs on Property Values: A Case Study of A Hazardous Waste Site." *Risk Analysis*, Vol.10, No. 4, pp. 485-497.

McCarthy, Linda. 2001. Brownfield Redevelopment: A Resource Guide for Toledo and Other Ohio Governments, Developers, and Communities. Toledo, OH: Urban Affairs Center, The University of Toledo.

The National Round Table on the Environment and the Economy and The Canadian Brownfields Network. 2005. Greening Canada's Brownfields: A National Framework for Encouraging Redevelopment of Qualifying Brownfields through Removal of Crown Liens and Tax Arrears.
http://www.nrtee-trnee.ca/eng/programs/Current_programs/Brownfields_Strategy/Documents/Brownfields-Liens/Brownfield-Liens-1-Introduction_E.htm

Port of Portland, Portland Development Commission, City of Portland METRO. 2004. Brownfield/Greenfield Development Cost Comparison Study. Portland, OR: Portland Development Commission.

Schopp, Danielle. 2003. From Brownfields to Housing: Opportunities, Issues, and Answers. Washington DC: Northeast-Midwest Institute.

Simons, Robert A. 1998. Turning Brownfields Into Greenbacks: Developing and

Financing Environmentally Contaminated Urban Real Estate. Washington, DC: Urban Land Institute,

Sousa, Christopher A De. 2002. “Measuring the Public Costs and Benefits of Brownfield Versus Greenfield Development in the Greater Toronto area.” *Environment and Planning B: Planning and Design*, Vol. 29, No. 2, pp. 251-280.

Urban Institute, Northeast-Midwest Institute, University of Louisville, and University of Northern Kentucky. 1997. The Effects of Environmental Hazards and Regulation on Urban Redevelopment. UI Project No. 06542-003-00.

U.S. Congress. 2002. The Small Business Liability Relief and Brownfields Revitalization Act. http://www.epa.gov/swerosps/bf/sblrbra.htm

Wang, Pingo, Bohara, Alok K., Berrens, Robert P., Gawande, Kishore. 1998. “A risk-based environmental Kuznets curve for US hazardous waste sites.” Vol. 5, No. 12, pp. 761 – 763.

Warren Group. 2006. Housing Transaction Data in Massachusetts.

White House Council on Environmental Quality. (2004). Over 1,000 to be Trained for Environmental Jobs in Brownfields Communities Nationwide. CEQ E-Notes, 2(13).