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DISSERTATION

ECONOMIC DEVELOPMENT IN THE INNER CITY

Submitted by

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Department of Economics

In partial fulfillment of the requirements

For the Degree of Doctor of Philosophy

Colorado State University

Fort Collins, Colorado

Fall 2005

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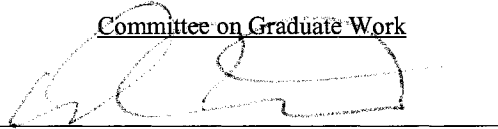
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WE HEREBY RECOMMEND THAT THE DISSERTATION PREPARED
UNDER OUR SUPERVISION BY BENJAMIN WIDNER ENTITLED ECONOMIC
DEVELOPMENT IN THE INNER CITY BE ACCEPTED AS FULFILLING IN PART
REQUIREMENTS FOR THE DEGREE OF DOCTORATE OF PHILOSOPHY.

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ABSTRACT OF DISSERTATION
ECONOMIC DEVELOPMENT IN THE INNER CITY

This dissertation is comprised of three sections related to the development challenges in the inner city. It begins with an examination of retail opportunities in the inner city then moves to some of the issues with development hurdles in the inner city and finally looking at the impact to housing with respect to hazardous properties. The fundamental theme linking these topics together is highlighting opportunities for development of overlooked areas. Given the recent focus on inner city areas this dissertation provides some rationale for investment in often overlooked sights.

The first segment examines the outflow of funds from economically challenged areas. While the inner city areas struggle to provide goods and services to their residents an opportunity arises for public institutions as an information provider. By highlighting those areas with the greatest need retail gaps can be narrowed in these areas.

Building on the first segment, the second contribution focuses on environmentally damaged properties often found in economically challenged areas. This section surveys investors to determine the significant premium placed on environmentally damaged sites. This investigation is crucial in understanding the extra burden placed on investors of environmentally damaged sites.

Finally, the impact of environmentally damaged sites on housing values is examined in the concluding section of this dissertation. To determine the impact an examination of current spatial economic modeling is performed. While examining these

impacts a new approach to modeling the spatial impacts is tested. The resulting model improves the forecasting power of the traditional hedonic models.

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It has been said the friends you make in graduate school are like brothers in arms. I do not have enough space here to thank all the friends I have gained during my time at Colorado State University. My time in graduate school would have been very different without the late night study sessions, numerous social events, and the outdoor fun. In addition, I gained a greater knowledge of lives and cultures beyond our borders. The experiences and knowledge gained from these friendships will be something I will treasure for all my years.

In closing I owe a great deal of my success and fortune to mi familia. Bridgette, Breanna, and Ben are my source of support and motivation. Bridgette you have stood strong by my side through all my trials and tribulations. Breanna and Ben you provide the inspiration for my labor and the welcomed escapes from work. I thank you with all my love.

Any errors in this work are solely the author's responsibility.

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CHAPTER I INTRODUCTION

Section 1.0 Background

It takes only a short drive through a metropolitan area to notice there are some overlooked regions. A drive down I-25 from Fort Collins to Denver yields some beautiful views of three to four story mansions in the outlying suburbs. As you enter the city, you are greeted with abandoned business districts immediately followed by a rejuvenated downtown area. This irregular development exists in cities in the west as well as many metropolitan regions around the country.

Through a series of papers I highlight the struggling inner city areas and investigate possible market failures that arise from poor information. Highlighting the abandoned districts as business opportunities can provide rationales for private and public development. Many times the vacant property in the inner city is environmentally damaged from the previous tenant. Cleanup of this area will not only improve its own property value but also increase values of the properties in the surrounding area. Current spatial econometric techniques are used to evaluate the impact of environmentally damaged sites on neighboring property values. Improving on these techniques I introduce spatial variables to the traditional hedonic models. The inclusion of these spatial variables allows for a more robust model for estimation.

It is my intention to use these areas of economic research to highlight the development potential of inner cities. First, I must establish these areas are underserved. If they are indeed underserved I will examine the private incentives to invest in these

areas and the returns to that private investment. Given the low margins to private entrepreneurs the cost of information is significantly high enough to cause a barrier to entry. Following is an analysis of environmentally damaged sites and the hurdles they face in terms of development. Even when the cleanup cost for these sites is known with certainty, a wedge still remains crowding out private investment. This wedge represents an additional hurdle to development in the inner city. Finally, I will improve on current spatial econometric techniques to include spatial variables into the traditional hedonic model. These spatial variables are an alternative estimation technique to the current spatial weighting matrix used today.

Section 1.1 Retail Leakages

My first hypothesis I plan to test is: Is there a net outflow of retail spending from the inner city area of Denver? That is does Denver follow the national trend of resources flowing from thin markets to flourishing suburbs. If indeed this is the case in Denver, the next question asked is why has private capital not rallied to fill the retail gap. One possibility is the lack of clear information on opportunities in these areas. Public institutions have a unique opportunity to translate and provide information to local communities and entrepreneurs.

This chapter assesses retail gaps between local household demand and current retail sales supply. Upon discovering these retail gaps a small establishment is introduced to determine why the gaps may persist. Given the low margins to a profitable establishment it is clear that the cost of acquiring information on inner city opportunities is too great considering the limited budget.

The cycle of neglect in these areas is destined to repeat itself given a lack of private investment or public attention. The initial starting point of this cycle is often under debate; was it the corner store closing down or the movement of a major employer out of the area? The catalyst(s) begins with a few boarded up buildings, then a few more, before long the quality of the abandoned properties rapidly decays. No matter the initial cause of neglect the pattern has been established and must be reversed if the inner city is expected to once again be a productive part of the municipality. If private incentives are not sufficient to spawn development then there may be a role for public involvement in the redevelopment process.

Given the potential public sector role in addressing this cycle of neglect, there have been many recent initiatives from the federal, state, and local government attempting to highlight some of the opportunities presented in these overlooked regions. These initiatives point to the low factor prices, underserved demand, and centrality of these areas as offering strong comparative advantages to more established business sites (e.g. Porter, 1997). However, many of these programs have focused on the downtown areas for redevelopment such as LODO in the Denver area, the waterfront in Downtown Boston, and retail shops in Southside Chicago and Oakland. This has created a ‘donut’ effect in most metropolitan areas. Denver’s donut spans in a semi-circle from southwest Denver to the northeast section. (See [Appendix](#) Figure1-1 and 1-2 for maps of Denver’s donut). This change in the inner city shows guided efforts are able to reverse the stagnation that once existed in the center of major metropolitan areas. However, now the focus must be shifted beyond the city core to the new ‘inner city’ neighborhoods.

Section 1.2 Brownfield Redevelopment

Continuing the theme of struggling inner city areas this chapter examines the actual properties in the struggling neighborhoods. Many of the abandoned properties in the inner city contain some form of environmental contamination or possible stigma from previous uses. The presence of environmental damage or just the possibility of damage can significantly reduce the attractiveness of site redevelopment, which will be determined by a developer survey included in the appendix. However, these sites may produce considerable returns to investment, and positive externalities from cleanup. The increased economic activity in development of these sites is often mentioned however rarely is the impact to the surrounding property mentioned.

As noted above, brownfields' environmental stigmas may make such sites particularly unattractive to investors, despite the broader social returns that their redevelopment is likely to produce. The city of Denver recognizes the benefits of redevelopment and has taken a first step in purchasing neighborhood brownfield properties for cleanup. However, the bulk of redevelopment activity necessarily requires private sector involvement.

Therefore, information on the benefits and costs of redevelopment, including realistic assessments of risk premia, needs to be channeled to local redevelopment agents: developers, realtors, real estate financiers, and their collaborators, and clients. The additional hurdles facing development agents when evaluating brownfield sites are critical to understanding private investment incentives. Therefore, I will use the results from the developer survey to clarify the impact of brownfield stigma on investment

decisions. This survey of local development agents will give a clearer picture of the willingness of investors to take on risky investments as well as differentiating between real and perceived costs of environmental damaged sites.

Section 1.3 Spatial Dependence in Econometric Models

The final paper completes two tasks. The first is determining if surrounding properties are negatively affected by the presence of environmentally damaged sites, and the second improves on current spatial econometric techniques by introducing an alternative estimation method.

These damaged sites provide a challenge to econometric analysis. Current hedonic house pricing models rely on the attributes of homes to determine their value. The presence of an environmentally damaged site has been found to lower the value of house prices (Kohlhase 1991). Kohlhase used large scale Superfund sites in her study to estimate impacts. However, these sites are not the focus of my studies.

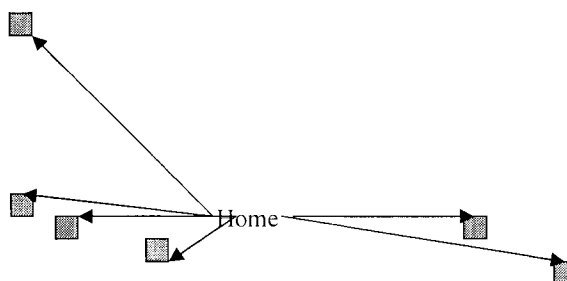
The inner city areas I am evaluating are often faced with smaller scale environmentally challenged sites. These environmentally challenged sites are often referred to as brownfields. Brownfield sites are defined as: “real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant.”¹ There are certain legal exclusions such as those sites listed on the National Priorities List (NPL) and sites that are under a redevelopment plan already.

¹ According to Public Law 107-118(H.R. 2869- "Small Business Liability Relief and Brownfields Revitalization Act" signed into law January 11, 2002.

A model is developed to assess the impact of these brownfields on housing prices, employing current advancements in spatial econometrics to improve on the traditional hedonic models. Spatial econometrics examines the relation between spatially dependent variables which applies to housing prices in a neighborhood. The value added from using spatial econometrics is reducing some of the bias in estimates often present in traditional hedonic models. Brasington and Hite are the first to apply this modeling technique to traditional hedonic models. However, one drawback to the spatial estimation is the lack of flexibility in the weighting matrices currently used. The main flaw is that an estimation of our weighting matrix is dependent on a single rho while my approach is infinitely divisible and statistically testable. The two approaches will be used to determine the impact of brownfields, and accuracy of the two models will be compared.

For this analysis, I will add a variable to measure the distance of home from each individual brownfield. In addition using Excel and a Visual Basic script I will create an average housing price variable at multiple distances. Some advantages of the linear distance method are the ability to easily convert these to saturation or count indexes. In addition, a separation of contamination types is possible under this scenario. This linear

distance is depicted in the graphic below:



■ Brownfield

The small amount of literature on this subject is thoroughly examined, and my estimation technique proposes some improvements to the current studies. The concept of brownfield impacts and associated effects of redevelopment is a relatively new and expanding area of study in the economic literature. Much of the work on contaminated sites has focused on large scale sites and overlooked the large number of small brownfields that exist throughout the cities. However recent interest by federal agencies and local cities has sparked a new round of research. The debate of infill versus sprawl has forced a re-evaluation of inner city properties.

The Environmental Protection Agency has made a considerable effort to redevelop the brownfields located in urban areas. "EPA's Brownfields efforts are a real attempt to bring business and government together to make a big difference for local communities," said William Kovacs, U.S.Chamber of Commerce Vice President of Environmental Policy. In a speech in November (2003) by EPA Administrator Christine

Todd Whitman she states, “To date, EPA’s brownfields assistance has leveraged more than \$4.6 billion in private investment, helped create more than 20,000 jobs and has resulted in the assessment of more than 4,000 properties.”

CHAPTER II RETAIL LEAKAGES

Section 2.1 Overview

The chapter begins with the hypothesis that the inner city is underserved in retail services. If indeed they are underserved, then why have new capital and businesses not entered the market to fill this gap? One possible reason is the lack of clear information on conditions in these markets. Given low margins available to small businesses the compiling and transformation of data is virtually impossible on such a small budget. This provides an opportunity for public institutions-for instance, universities to-collect, analyze, and disseminate the information. This chapter will examine whether Denver is underserved and how filling the informational gaps helps improve the situation for these inner city neighborhoods.

The apparent sequence of inner cities' economic struggles may be explained by the continuing lack of investment in these neighborhoods. During the turn of the millennium I was part of a team consisting of Colorado State University and Denver researchers developing a template to estimate retail opportunities in neglected inner city neighborhoods of Denver. The group has made a considerable effort to use publicly available data so the template can be easily applied to other areas facing similar obstacles as Denver.

This chapter begins by first identifying the struggling areas of the city of Denver based on socioeconomic data. Once the area of study has been established it must then be determined if these areas of Denver are indeed underserved. Retail gaps will be estimated

through comparing the current purchasing power (demand) with the sales (supply) in the area. An excess of demand in these retail areas would constitute a gap or lack of services provided in the neighborhood. Given the existence of a gap the attention then turns to the market to fill these opportunities. However, as examined in the final section the market may not be able to correct this gap without some aid from the public sector.

Section 2.2 Area of Study

The focus areas were obtained using two methods of analysis. Social indicators such as crime, high-risk births, public assistance education and housing were examined by the city of Denver. These indicators were then converted to a weighted indicator and converted to a composite index to reflect the distress of each neighborhood. These results were part of a broad redevelopment plan referred to as Blueprint Denver.

Economic characteristics were then evaluated. In the area of study, there are a large amount of vacant properties. According to the 1990 Census unemployment rates are also among the highest in the city. For example in the 80205 zip the unemployment rate for individuals age 16 to 19 is 38%; in addition, 38.6% of 18 to 34 year olds are under the poverty level. In the 80219 zip code, which contains Westwood, the eventual focus of the brownfield analysis, the unemployment and poverty level rates are 32.9% and 21.3% respectively. (See [Appendix Figure 2-1](#) for complete table). Although the analysis is done with 1990 data, the situation in the inner city has not improved.

The 1990's were a time of record growth throughout the nation, and Denver was no exception. The 2000's census provided a record of the economic prosperity we enjoyed in the previous decade. While things improved throughout the city, the inner city

target areas were still lagging behind as you can see in [appendix figure 2-2](#). For the 80205 zip code unemployment dropped to a rate of 13.9% just above a 50% reduction in unemployment. However, Denver overall had an above 50% reduction in unemployment of 16-19 year olds for the 10 year period.

Poverty rates and median household income improved somewhat yet they are still the lowest in the city. The 80203, 80204, and 80205 zip codes all have median household income well below \$30,000 a year while Denver as a whole has a median household income of nearly \$40,000. Poverty rates in these the 04 and 05 zip codes are almost 30 percent. In education Denver enjoys a 35% population with college education or greater, seven of the nine target areas fall well short of that rate. So while things have improved in the area the socioeconomic struggle continues to persist in these regions.

Both social and economic rankings were combined to determine targeted areas in the inner city. A final list of target areas includes the following zip codes 80203, 80204, 80205, 80207, 80211, 80216, 80219, 80223. The zip codes form a semi circle from the southwest to northeast corner of Denver. For a graphical representation refer to the highlighted areas of Figure 3-2 in the appendix. These areas represent the new inner city struggling socially and economically well below the average for Denver. Even in the areas where unemployment numbers decreased the percentage of population in the workforce decreased. The decrease in poverty rates is promising yet still far behind Denver as a whole.

As expected with the struggling economic statistic above there is also a large amount of unused land in the area of study. The total vacancy rate for the Denver metro area is 17.7 percent as compared to the vacancy rate in downtown Denver of 5.8 percent

(Q3 2004). Utilization of vacant office space represents a lower social cost to society than those currently being used for other retail activities. Combined with the large unemployment in the area the use of vacant land and idle labor will have some positive social impacts beyond the items they produce.

Section 2.3 Assessing Retail Leakages

H₀: Inner cities are underserved in retail services

Inner cities are facing uneven retail spending patterns and this was the focus of HUD's "State of the Cities, 1999." Items that were particularly in demand in inner city areas included food at home and clothing. According to the city the problem is far reaching and not limited to any particular city or region. The hypothesis tested in this section is whether Denver indeed follows the trend and contains underserved intercity areas.

This chapter begins with the hypothesis that socioeconomic challenged areas of the inner cities are underserved. Do the areas of lower economic activity face a deficit of retail services when compared to other regions? To begin answering this question an area of study must be compiled. This struggling area is first defined then an assessment of retail activity is undertaken to assess the presence of retail gaps. If they are indeed underserved how the retail gaps are created will be examined in the subsequent section.

The area of study is Denver, Colorado. A definition of Denver's inner city was determined by economic indicators and social indicators to establish areas of need. The initial data was collected at the census tract level given its availability. However, since business decisions are made on a larger scale and census tracts are very small areas the

data was scaled up to the zip code level for the retail analysis. Each target census tract was matched to the zip code with which it fit most closely.

As mentioned previously inner city areas have a potential for redevelopment efforts. The unique concentrations of purchasing power may provide significant opportunities for investment in these areas. This hypothesis was tested for inner city Denver (Weiler et al, 2003).

Retail expenditures were estimated using household and income data from the Bureau of Labor Statistics Consumer Expenditure Survey (CES). The CES survey did not match retail SIC categories directly so a matching process was enacted to ensure the best fit. The estimation of individuals' expenditures on retail items as a function of their income was then tested in several different functional forms. When the appropriate function form was finalized a demand equation was estimated.

Using this estimation of demand, each zip code's average income was introduced into the equation. The result gave an estimate of household expenditures in each zip code. Next, the zip code's household expenditure figure was plugged into the remaining retail equations to find expenditures in each category. Finally, this number is then multiplied by the number of households in each zip code resulting in an estimate of total expenditures for each category. These calculations were carried out by a fellow researcher and the full details may be found in the Weiler et al (2003) publication.

In order to assess the retail gap in particular areas, the demand expenditure results need to be compared to estimates of sales supply. However, accurate sales data are especially difficult to obtain, particularly given data disclosure issues. This employs a practical method that can extrapolate retail sales from easily accessible establishment size

class count data (i.e. number of establishments with 1-4 employees, 5-9 employees...).

With a sufficient number of observations, the approach can estimate a consistent relationship between establishment size counts and sales. Larger establishments have more employees and more sales. While estimating sales based on such size class measures is a simplification of a complex process, the method's use of public data and its success in estimation suggest that the approach has broad utility. The supply side regression analysis was done to estimate the following function:

$$Sales=f(Establishment\ Size\ Class\ Count).$$

Establishment size counts are detailed in this analysis as MX1-MX9, which identify establishment size class by the number of employees.

MX1= 1-4

MX4= 20-49

MX7=250-499

MX2= 5-9

MX5= 50-99

MX8= 500-999

MX3= 10-19

MX6= 100-249

MX9= 1000+

To determine benchmarks for the supply side of the analysis, the 1992 Economic Census and 1992 County Business Patterns data for the western region of the U.S. were used. Sales figures were obtained from the Economic Census, while establishment size counts were taken from County Business Patterns. A total of nearly 400 western counties were used as the basis for estimating the sales-to-establishment-size-count relationship. In the initial compilation of the County Business Pattern and Census data, no proprietor businesses were included. These stores produce less than five percent of retail sales, but still can be marginally important in evaluating an area's retail promise. The Non-Employer Census report was therefore used to include these establishments in our final data set by adding the proportion of their sales to traditional employer statistics. This

allowed compilation of a complete data set with 1992 sales and establishment size class figures, which could then be related through econometric methods.

The western region's data were further segmented into MSA and non-MSA areas, as there are unique properties of retail establishments for metro and non-metro markets. For example, a retail store in a non-MSA area may supply a broader range of retail items with fewer employees but be reported as a single SIC category. Therefore, MSA patterns were used to evaluate the sales-establishment relationship in all categories. Regressions were then run using the more than 240 remaining western metro counties to estimate the establishment/sales relationship. Various combinations of establishment size classes (e.g., summing the one to four and five to nine size classes into a one to nine variable) were explored. In the end, such combinations were not used as they did not improve the explanatory powers of the model. Each sector was also scrutinized for dissimilar characteristics between Denver and the western region sample. For instance, in Denver the food sector (5400) has no establishment in the size classes of 250-499, 500-999, and 1000+. Therefore, counties such as Maricopa County in Arizona needed to be removed, since Maricopa County has fifteen establishments in the 250-499 size class. The same process was followed for each two-digit SIC category. Deletions were made as needed on a two-digit level to each county's data. If a county's food category was mismatched but home furnishings and apparel did match, observations for the food category were omitted, but those for home furnishings and apparel were included. This refined data set thus more closely matches Denver's characteristics.

Multiple regressions were run to test the different data formats, functional forms, and econometric correction procedures. A quadratic model was found to be the most suitable functional form, with a structure here of

$$\text{Sales} = \sum_s a_s [\text{EstSizeClassCountS}]^2 + b_s [\text{EstSizeClassCountS}] + c$$

estimated over all the 9 establishment size classes, S. This function produces a parabolic function with direction, width, and intercepts depending on the parameters a, b, and c. Quadratic functional forms exhibit diminishing returns to scale when $a < 0$. As the establishment size grows, sales increase at a decreasing rate and could in fact decline at high-count levels. Increasing returns, where $a > 0$, are possible as well.

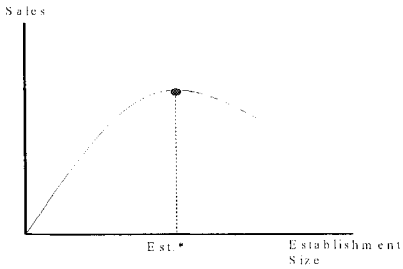


Table 2.1 describes the final regression findings; standard errors are in parentheses. The high adjusted R-squared is a first signal of goodness of fit. Furthermore, tests of the method against known 1992 and 1997 results through census and other local data show estimate errors in the range of 1–2 percent. Note that variables remained included even if insignificant; since the goal is a full system with which to estimate sales based on establishment size class counts. In that sense, the estimation process focuses on systemic prediction rather than maximizing the t-statistics of any individual coefficient.

Table 2.1 Sales as a Function of Establishment Size Regressions

| Variable | 5400 Food Stores | 5600 Apparel and Accessory | 5700 Furniture And Home Furnishings | 52-- Retail Trade |
|---|-----------------------------|-------------------------------------|--|--------------------------|
| MX1 | 476.2621* (228.34) | 505.2754* (88.47) | 289.7442 (202.58) | 43.71645 (422.90) |
| MX2 | 71.41176 (815.17) | -26.07838 (240.10) | 981.7817* (435.51) | 2117.986 (1350.95) |
| MX3 | -578.4552 (1542.18) | 126.1391 (898.84) | 1968.871* (909.68) | 1002.777 (1781.89) |
| MX4 | 7069.985 (2049.05) | 5005.113* (384.29) | 826.5927 (1534.67) | -1862.642 (2576.95) |
| MX5 | 11096.04* (1832.12) | 16944.81* (2600.49) | 10235.38* (3864.73) | 19193.347* (4186.66) |
| MX6 | 22412354* (2870.45) | -23791.45* (9268.35) | 23801.94* (4684.55) | 8835.953 (6437.73) |
| MX7 | 56955.7* (16361.11) | 53397.26* (9067.34) | 102672 (39534.38) | 21489.48 (28662.45) |
| MX8 | N/A | 93311.75* (42088.71) | N/A | -893.2909 (59896.45) |
| MX9 | N/A | N/A | N/A | 565663.6 (253593.3) |
| (MX1)² | 7.088828* (2.97) | 1.654997* (0.74) | -6.278224* (2.33) | 0.142172* (0.09) |
| (MX2)² | 6.240293 (12.52) | 2.568382 (2.30) | 3.872559 (5.00) | -1.041636 (0.55) |
| (MX3)² | - 80.64788* (27.56) | -46.40019* (11.10) | 96.29116* (26.96) | 0.774623 (1.02) |
| (MX4)² | 29.46912 (18.41) | -1102.15* (216.25) | 543.4912 (295.95) | 0.970077 (2.75) |
| (MX5)² | -14.18239 (74.60) | 32343.17* (4359.11) | -1989.026* (657.21) | 2.909539 (7.35) |
| (MX6)² | - 11001.25* (3026.48) | -11176.09 (3566.67) | -102266.1 (33645.38) | 20.85708 (49.04) |
| (MX7)² | -127182.1 (35252.72) | 16668.48 (30636.64) | -35083.76 (32703.30) | 59.77519 (1595.54) |
| (MX8)² | N/A | 32122.46 (205499.5) | N/A | -20754.05 (10701.27) |
| (MX9)² | N/A | N/A | N/A | -493936.6* (132844.2) |
| Adjusted R² | 0.998333 | 0.999064 | 0.997369 | 0.999055 |
| Standard Errors in parentheses With significant values (*) at the .05 level. | | | | |

Indeed, all establishments work together as a system in this context. Larger establishments are likely to substitute for multiple smaller ones, which pioneered a market niche and developed associated supplier links. In general, new stores create positive new first-order sales; negative first-order coefficients are generally insignificant, but remain included preserving a complete system. The MX6 apparel exception demonstrates the potential effect of substituting a larger, less efficient store for several smaller ones. In general, second-order decreasing returns to larger-scale operations occur in each of the categories. For example, considering the retail MX5 and (MX5) variables, the addition of one establishment in this size category will have positive effects on sales, but the squared term reduces sales. As establishment size grows, this squared term has a proportionally larger impact on sales, creating the increasingly explicit effects of decreasing returns. Interestingly, several stores sizes exhibit increasing returns (i.e., $a > 0$), suggesting varying scale economies.

Given the establishment size count to sales relationship estimated by the noted econometric method, one can then simply introduce an area's establishment size class characteristics to estimate the level of sales from these establishments. In this case, the counts available from the 1997 Zip Code Business Pattern data were used to estimate 1997 sales in the target zip codes.

The relationship of expenditures with local sales yields an estimate of local opportunities. That is, areas with expenditures greater than sales would have a retail shortage or they are under retailed. Areas with expenditures less than sales would be a net exporter to other regions. The regions studies were broken down by their zip codes. The main area of focus for the retail establishment is SIC Major Group 54 (Food Stores).

Table 2-2 1997 Food at Home

| Zip | Expenditures | Sales | Gap | Gap/HH |
|---------------|---------------------|---------------|----------------|---------------|
| 80207 | \$24,856,860 | \$4,270,776 | (\$20,586,084) | (\$2,690) |
| 80203 | 31,991,946 | 17,721,368 | (14,270,578) | (1,286) |
| 80211 | 41,079,982 | 32,366,443 | (8,713,539) | (609) |
| 80223 | 21,666,893 | 15,804,124 | (5,862,769) | (786) |
| 80205 | 25,276,200 | 28,815,263 | 3,539,063 | 396 |
| 80216 | 7,992,122 | 14,083,640 | 6,091,518 | 2,134 |
| 80204 | 33,787,313 | 45,539,386 | 11,752,073 | 973 |
| 80218 | 29,825,120 | 69,188,947 | 39,363,827 | 4,240 |
| Sum | \$272,172,528 | \$330,546,704 | \$58,374,176 | \$632 |
| Denver | | | | |
| Total | \$664,860,809 | \$875,565,872 | \$210,705,064 | \$969 |

As shown in the table above, out of nine focus zip codes, four contained a retail shortage with respect to food stores for the 1996 target year. The amount of households present in these areas is well over forty thousand. Mean income in the area was under \$35,000 yet the density of the area provides a viable retail demand. If new establishments were to capture only fifty percent of the unfilled demand it would result in 7 new establishment employing approximately 152 individuals, almost \$3 million in new income for the area, and approximately \$25 million in sales revenue. These results are shown in table 2.3 below:

Table 2.3 50% Capture of Local Gap 1997 Food at Home

| Zip | New Est | New Emp | New Inc | New Sales |
|--------------|----------------|----------------|----------------|------------------|
| 80207 | 3.0 | 63 | \$1,233,356 | \$10,293,042 |
| 80203 | 2.1 | 44 | 854,980 | 7,135,289 |
| 80211 | 1.3 | 27 | 522,046 | 4,356,769 |
| 80223 | 0.9 | 18 | 351,251 | 2,931,385 |
| Sum | 7.2 | 152 | \$2,961,634 | \$24,716,484 |

Identification of these opportunities implies our hypothesis is correct and these areas are indeed underserved. However, what are the conditions that allow this retail gap

to prevail in the inner city. One possible contributing factor is the lack of information to entrepreneurs hoping to locate in the dense inner city area. The lack of easily accessible data on business transactions and economic conditions can cause some gaps to persist in underserved struggling areas.

Section 2.4: Information Gaps and Stagnation

Informational gaps are likely to exist in smaller entrepreneurial businesses since large establishments tend to have much higher budgets and research staff used to analyze market conditions. This section looks at the information gap hurdle and how small businesses may be adversely affected by this market failure. It also produces an opportunity for public intervention by filling these information gaps.

The cycle of neglect in the inner city area is in part a function of previous neglect, as bypassed investments lead to limited information on local prospects. This cycle of economic stagnation reduces the incentive for private capital to invest in these areas. Lack of investment by private capital is not the sole problem affecting these inner cities (Weiler et al., 2003). Yet the information gap is an issue that we are in a position to address and provide insights to these underdeveloped regions. The university setting provides a unique opportunity to bridge the gap between government officials and private enterprise.

The traditional business data that is found in thicker affluent market areas with continuing investments is not readily available in the inner city or rural regions with thinner realty, labor, and entrepreneurial markets. The informational gap forces decision makers to place a greater weight on potential risk given the lack of data points. The

missing information is crucial to business investment selection. A business will require information on local economic prospects before making a move to that area or expanding local operations. This information may include but is not limited to market area demand, labor market conditions, government involvement, potential and current competition. However, there will likely exist information asymmetries between markets given the unbalanced levels of transactions. Thriving markets will contain more information than 'thin' or challenged market areas (Scorsone and Weiler 2004).

Much like Akerlof's (1970) well known lemons model, the information gaps can cause a reliable market to fail to exist. These informational gaps can be the catalysts that entrench the problems of inner city areas, with neighborhoods facing a unique adverse selection problem. Nakamura and Lang (1993) show the path dependence of stagnation that can occur in such thin markets due precisely to such informational hurdles. In considering the mortgage markets, information on properties' actual value is crucial to financing purchases. A low number of transactions in a stagnating market imply poor information and high variance of potential appraisals. Therefore, financing institutions will be less likely to provide loans to these markets, ensuring a cycle of neglect and marginalization. "Gains in appraisal precision from increasing lending activity will be greatest in thin markets" (p227), which they suggest is an efficiency-enhancing way of prioritizing public resources.

The public benefits gained from employment of slack resources, increases in community fabric, decreased travel costs, and many other benefits suggest an increasing role for institutions in developing these neighborhoods. Yet these broader community benefits need to be explicitly assessed alongside private development incentives.

Given large establishments are likely to have a plethora of business information smaller establishments are at a disadvantage. With large fixed costs of acquiring information small businesses are unlikely to invest the time or effort of collecting this data in less established neighborhood. The small businesses will migrate toward the well established markets that need no attention. To examine this phenomenon closer we can look at the restrictions and profitability options faced by entrepreneurs.

Establishment of a 10,000 square foot in the inner city will be used to determine private profitability in a small retail establishment. Private profitability estimation is straight forward using current accounting methods. Typical operating expenses and revenue estimates make up the returns to the store owner. The results of this establishment are given below.

Table 2-3 Model 10,000 square-foot Store

| | | |
|--------------------|-----------|-------------|
| Gross Sales | | \$3,717,900 |
| Cost of Goods Sold | | (2,775,881) |
| Gross Profit | | \$942,019 |
| Labor | \$445,746 | |
| Rent | 142,200 | |
| Interest | 27,822 | |
| Other Net Expenses | 263,387 | |
| Operating Expenses | | (879,155) |
| Before Tax Profit | | \$62,864 |

To calculate the private returns pre-tax profits (\$62,864) are divided by operating expenses (\$879,155), which yields a private rate of return of 7.15%. Such a low rate of return provides some insight as to why investment might not occur on its own given the large amount of annual investment required and thin-market risk involved. Yet the absolute pre-tax profits do provide compensation approximately equal to an inner city

entrepreneur's opportunity cost of time, which could motivate investment in a locally managed operation.

These retail gaps may be persisting through a lack of information on economic opportunities as well as the high costs associated with obtaining this information. If the entrepreneur is facing only a marginal return of seven percent they have very little incentive to spend a large amount of time and effort in calculating retail gaps in struggling areas. The cash strapped entrepreneur will gravitate toward the thriving markets where information is more readily available to both the store owner and business investors.

This raises the question of who is left to fill the informational gap and impede the cycle of neglect in these areas. A private store owner has neither the funds nor resources to provide that information. Large corporations have their own proprietary sources of data which they are unwilling to disseminate. This leaves the public sector to determine an avenue for assimilating relevant data and distributing it to the appropriate individuals. As public institutions universities are well equipped to bridge this informational gap while continuing their service to the community.

The study completed by Colorado State University funded through the Economic Development Association was distributed among many members of the Denver area. The outlined opportunities in the inner city were distributed by the mayor's office to small business associations in the area. The information was also picked up by news reports in local and national press. The Piton foundation and many local community associations also made use of the information provided in the study. The rapid circulation of the project results combined with a majority of positive comments show there is a thriving

market in need of these types of projects. The results are not likely limited to Denver as many urban areas are looking to revive their once thriving inner city areas.

Section 2.5 Summary

The analysis above argues for public institutions' involvement in the development of neglected inner city areas, at least in terms of information provision. Given a cycle of neglect and lack of information in these areas, private investors will not invest their capital in these neighborhoods without motivation. The returns to a private entrepreneur are relatively low and appear to be more risky than in the developed 'thick' markets. In addition the cost of collecting this data is quite large for a single business operator, yet it is required by investors and insurers of the business. However, the social benefits gained from development in these areas may be significant enough to warrant public institutional involvement, both in terms of information as well as use of public resources.

The results of this section show considerable outflows of sales, income, and jobs from an already struggling community. A capture of half of these leakages in food stores alone would provide over 150 new jobs, almost 3 million dollars in new income, and over 24 million dollars in sales generated in these areas. The private returns to new establishments are slightly above 7%, and significant retail gaps are present in these communities. These narrow profitability margins facing the private investor lead one to consider whether they are missing some community returns that boost the social incentives to develop or redevelop these neglected areas.

CHAPTER III BROWNFIELD REDEVELOPMENT

Section 3.1 Background

The previous section dealt with assessing local retail gaps along with the associated private returns of development in the inner city. One of the motivations behind potential higher social returns in such areas is the relatively lower use of land resources, as indicated by high local vacancy rates. These neglected areas indeed tend to have a large number of vacant properties that are ready for redevelopment. However, some carry an extra burden of being environmentally damaged or contain an environmental stigma attached to them. The old corner gas station or laundry service operations have additional cleanup costs associated with development. Industries usually classified as brownfields are presented in Table 3-1:

Table 3-1
INDUSTRIES TYPICALLY ASSOCIATED WITH BROWNFIELDS²
AZ, CA, CO, ID, MT, NM, NV, OR, UT, WA, WY

| Industry Category | NAICS | No. Businesses | Avg. No. Employees |
|---|--------------|-----------------------|---------------------------|
| Agriculture, forestry, fishing, hunting, services | 11 | 7,782 | 9 |
| Automotive maintenance & repair | 81112 | 5,735 | 6 |
| Chemical mfg | 325 | 2,703 | 37 |
| Drycleaning & laundry services (except coinop) | 81232 | 8,811 | 7 |
| Fabricated metal product mfg | 332 | 13,544 | 22 |
| Gasoline stations | 447 | 19,625 | 9 |
| Hospitals | 622 | 1,249 | 640 |
| Leather & allied product mfg | 316 | 434 | 24 |
| Mining | 21 | 4,519 | 25 |
| Nonmetallic mineral product mfg | 327 | 3,276 | 27 |
| Paper mfg. | 322 | 926 | 75 |
| Petroleum & coal products mfg | 324 | 358 | 58 |
| Plastics & rubber products mfg | 326 | 3,361 | 40 |
| Printing & related support activities | 323 | 9,363 | 15 |
| Rail transportation support activities | 4882 | 142 | 22 |
| Recyclable material wholesale | 42193 | 1,699 | 13 |
| Sawmills & wood preservation | 3211 | 703 | 51 |
| Semiconductor mfg | 3344 | 2,363 | 97 |
| Waste treatment & disposal | 5622 | 478 | 25 |

As shown above these industries tend to have a relatively small number of employees but large in the number of establishments. A graphic of the environmental hazards facing Denver County are shown in Figure 3-1 and 3-2 in the appendix. In examining the distribution of the EPA hazards in this map we can see a distinct distribution of hazardous sites that overlaps our areas of focus. This overlap is most likely not a coincidence given the cycle of degradation discussed earlier.

Many papers on environmental justice focus on the issue of environmentally damaged sites located in areas of poor economic conditions. While the location causality

² Compiled by Development Research Partners from U.S. Census Bureau, *County Business Patterns* (1998).

of these brownfields is a compelling issue in itself, I will instead focus on the impact of brownfields on development in these areas. That is, what effect do brownfields have on the path dependent cycle of neglect and stagnation in these neighborhoods? As the neighborhood shops begin to close down and then the local gas or service station closes its door the likelihood of further investment in the area decreases. And so begins the cycle of neglect.

The existence of brownfields is not limited to large metropolitan areas. The businesses listed above exist in many communities including small rural communities such as Greeley, Colorado. Figure 3-1 through 3-3 give a view of the properties listed on the EPA's hazards lists located in Denver county, Denver, and the Greeley area. This may seem a bit shocking at first yet one can probably think of at least a dozen of these establishments in their own town.

These brownfields provide a challenge to developers yet their cleanup may have large social gains in terms of the development itself as well as its impact on neighboring property values. The next chapters will examine the impact of these brownfields on surrounding properties and estimate the benefits from cleanup.

Section 3.2 Literature review

Given the risk involved with environmentally damaged sites many investors tend to overlook these opportunities. Yet the effects of such persistent brownfields are not limited to the loss of the site's own potential use. The surrounding area also suffers a negative externality from associated perceived stigmas and resulting in bypassed investment. The cycle of neglect continues as long as no investor is willing to take the

risk of buying a contaminated site. Until the damaged property is cleaned up, businesses and residences surrounding that property will continue to be stigmatized, reinforcing the pattern of stigma and stagnation.

A large amount of work has been done to look at the impact of environmentally damaged properties on surrounding land values. Much of the initial work is focused on large-scale damages such as those posted on the National Priorities List (NPL) or Superfund sites. These superfund sites are properties that require federal assistance for their cleanup. Several studies have found a significant impact of these sites on the surrounding property values.

The inclusion of hazardous waste sites into traditional hedonic models began in the early 1990's. The addition of distance to a hazardous waste site into the attributes of an existing home showed a negative effect on the housing value. A prediction of these early models was removal of the site is equal to an increase in distance from the hazardous site (Michaels and Smith 1990). This implies a missing variable in traditional home pricing models. Just as a golf course, open space, or other amenities can add to the value of a home a disamenities such as hazardous waste sites can subtract from their values.

This idea is further supported from research done by Kohlhase (1991) examining the Houston housing market. Kohlhase collected data on the Houston housing market from 1976 to 1985. In addition to the housing characteristics, data was also collected on hazardous wastes sites that were placed on the NPL. A traditional hedonic model was again used but the NPL properties were included in the explanatory variables. The effect on home prices was found to be significant and negative but reversible. Once a site was

placed on the NPL list, property values in the vicinity decreased by a significant amount.

This is shown graphically below:

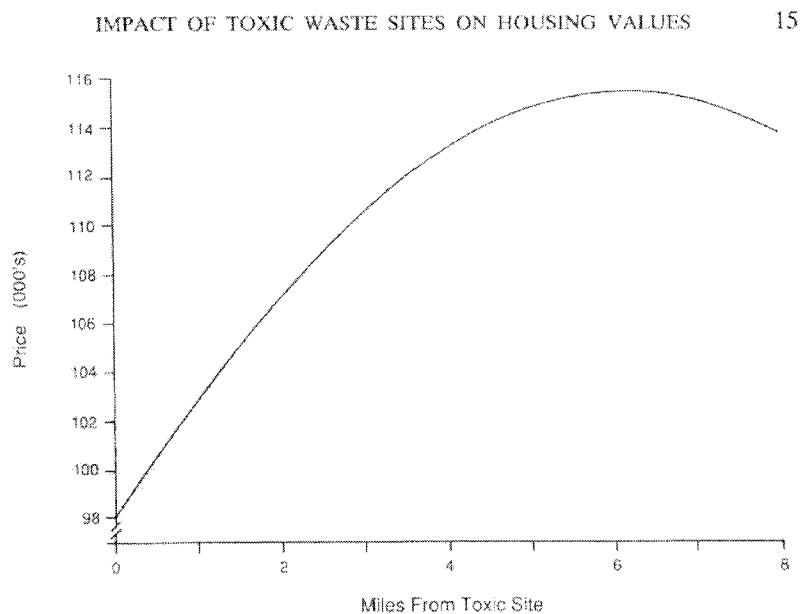


FIG. 1. Predicted house price and distance from a toxic waste site, 1985.

As you can see the predicted house price increased the further away from the toxic site. The effect seems to weaken only after 6 miles of space is placed between the house and the toxic property. However, after the site was cleaned up enough to justify removal from the list the effect was reversed. This has important implications for policy makers and cleanup incentives.

More recently Jackson (2002) observed the influence of contamination on industrial property values. Sales data was collected from southern California from 1995-1999 and properties were listed as contaminated, previously contaminated or non-contaminated. Other property characteristics were also included to distinguish differences in values. A negative effect on industrial property's value was found to be significant;

roughly a 30% decline on value can be attributed to contamination. Using an econometric approach Jackson was able to reveal “the temporary nature of ... the stigma effect for contaminated industrial real estate. None of the models analyzed produced any indication that the price effects of environmental contamination persist subsequent to remediation and cleanup. This is also consistent with findings from survey research...” (p198). The analysis showed that there was no significant difference in the sale price of properties that had been previously contaminated as compared to similar properties that had never been contaminated. Again cleanup effects were reversible and permanent.

Another line of research has shown an influence on property value to arise not only from actual contamination but perceived contamination as well. Gayer and Viscusi (2002) examined a relationship between housing prices and information on local hazardous waste sites. A hedonic property model was used with the perceived risks being measured by the amount of publicity (newspaper) given to the contaminated property. Data collected for this research was borrowed from a previous paper studying housing sales in Grand Rapids, Michigan from 1988-1993. However, data on homes sold less than once were omitted from the study. Their addition to the data set was inclusion of newspaper articles on hazardous waste sites sorted by date. The reasoning behind this was to obtain a measure of publicity before and after the sale of home occurred; and to determine any correlation that exists. The publicity was measured by the aggregate number of articles written about a particular site and by the number of words in each article. Their results produced an interesting result; newspaper articles on a given site tended to have a positive effect of \$100 - \$200 on the neighboring properties. This most likely occurred because once the contamination story was published probability of

cleanup increased. The articles may be calming peoples fears about contamination risks and draw attention to the cleanup efforts. The results may imply the adjustment back to fair value begins just before actual cleanup.

The above studies have all focused mainly on large scale superfund sites placed on the NPL. These sites only account for a small portion of the contaminated areas in a city and the cleanup is a very long tedious project. For example Denver, Colorado contains 3 properties that were listed on the NPL one of those sites is the former home of the Shattuck Chemical Company. Radium was used for commercial purposes in the early 1900s. Ore processing facilities in Denver provided a domestic source of radium. The radium industry collapsed in the 1920s, leaving numerous locations with radioactive residues. The residues were often used as fill or paving materials or simply left on site. The Denver Radium Site was added to the Superfund National Priorities List in 1983. It was not until June 2000 that the EPA decided to clean up the site for unconditional use. However, a development plan was not adopted by Denver until February 10, 2003³. Meanwhile, most of the surrounding properties have been cleaned up under the EPA's brownfield programs. A Home Depot store has been erected on two of the sites and is now generating revenue for the city. The large superfund sites have a sufficient amount of attention drawn to them while many smaller brownfield sites may be overlooked in the inner city areas. Denver has over 1,000 of these smaller sites listed as hazards by the EPA but not enough to place them on the NPL.

Recent work by Taylor and Ihlanfeldt incorporates these smaller sites listed as hazards by various government agencies into the hedonic pricing models. Data was taken

³<http://www.denvergov.com/admin/template3/forms/Shattuck.pdf>

for the area around Fulton County, Georgia which contains almost all of the City of Atlanta and the surrounding suburbs. The estimation compared price increase for properties close to hazardous sites before and after cleanup. The differences in the 'price gradients' were significant. They concluded the negative affect can be removed after cleanup. Policy implications suggested by their work is some form of cost sharing for the cleanup. Since neighboring properties both commercial and residential benefit from the cleanup they should bare some of the burden from cleanup. The major contribution by Taylor and Ihlanfeldt is the incorporation of these smaller brownfield sites and their impact on commercial and residential properties.

The research contained above has all been completed using traditional hedonic estimation models. However, the advancement of computing power and econometric techniques has provided the opportunity to improve on previous estimations. Using spatial econometric techniques we may be able to correct some problems found in typical regional data sets. I have found only one working paper by David Brasington and Diane Hite that use this estimation process for the effect of hazardous properties on surrounding property values. Their results find there is a demand for environmental quality when purchased with school quality. In addition they find environmental quality is a substitute for house size. The inclusion of the spatial econometric approach is very promising in terms of improved estimation. This will be further explored in the following chapter.

Section 3.3 Investment Informational Gap

The previous sections examined areas of concern for low economic activity in the inner city and the environmental stigma attached to many properties in these areas. The

perceived stigma of these properties may make developers circumvent these properties, leading to persistent gaps in parcel development. Information on the spillover benefits from brownfield redevelopment can help better assess the community impact of such efforts. To properly complete a private versus social cost benefit analysis, perceptions of development risk may also be added to the study.

The final section of this chapter will be to estimate the additional hurdle faced by entrepreneurs who decide to invest in these properties. As shown in the maps (Figure 3-1 and 3-2) there is a distinct pattern of brownfields that forms a semi-circle following the interstate outside the Central Business District and not extending into the suburbs. This area is also the focal point of retail gaps and location choice for our retail establishment above. In addition these neighborhoods are fraught with grim socio-economic indicators of the area. Unemployment in these areas is as high as 38% in the 16-19 age range. The population in these areas tends to be very dense and low income ethnic minorities. The population per square mile in Denver is 3,617 compared to 2,550 in Fort Collins, 2,782 for Phoenix-Maricopa County, 7,877 in Los Angeles, and 3,772 in San Diego.

The relationship above is not surprising given what has been discussed throughout this dissertation. Neglect breeds neglect, retail gaps persist, and brownfields tend to remain stigmas to the surrounding neighborhood. In general, those areas housing the most brownfields are also those with the most socio-economic struggles. Cause and effect may be difficult to disentangle. Do brownfields tend to cluster in areas with lower socio-economic status due to lower land prices, or are land prices (and related neighborhood socio-economic status) driven down by disproportionate brownfield clustering? As noted

previously, estimation of this relationship is beyond the scope of this dissertation, but the context of the question remains compelling.

In any case, brownfields can help make a neighborhood's effort at economic growth more difficult. As stated in previous works such as Kohlhasse once the site is cleaned up all effects of contamination is removed, but with no development prospects the land is likely to remain unproductive. This implies the full potential of the land is not being realized, and surrounding properties remain stigmatized as well. Cleanup thus provides broader social benefits that can be added to those sketched in Chapter 2.

Section 3.4 Developer Risk Premia

In this section the following hypothesis is made; Ho: Higher Hurdle rates for brownfields. The objective here is to assess the premium placed on brownfield properties. A survey of local development agents asks them directly about their investment attitude toward contaminated properties. The survey was sent to 900 metro Denver real estate development professionals, including those self-identifying as investors, developers, brokers, and financiers. The survey elicited background information on respondents' development roles, typical property types, and experience with and attitude toward contaminated properties. The core of the survey instrument asked respondents to consider a well-defined property type that was typical for them, and to tell what hurdle rates and other parameters they would set as criteria for the investment decision if the property were clean: overall capitalization rate, reversion or terminal capitalization rate, discount rate, and anticipated investment holding period.

Then, for the same property, respondents were asked to consider the effect on their criteria if the property required known clean-up costs equal to 15 percent of the “clean” purchase price. For the property in questions full clean-up costs are known and incorporated or offset through the eventual purchase price. This means that if any wedge still exists it is beyond the uncertainty of cleanup costs. For each of three cases --- gasoline contamination, dry cleaning contamination, and degreasing/solvent contamination --- respondents were asked:

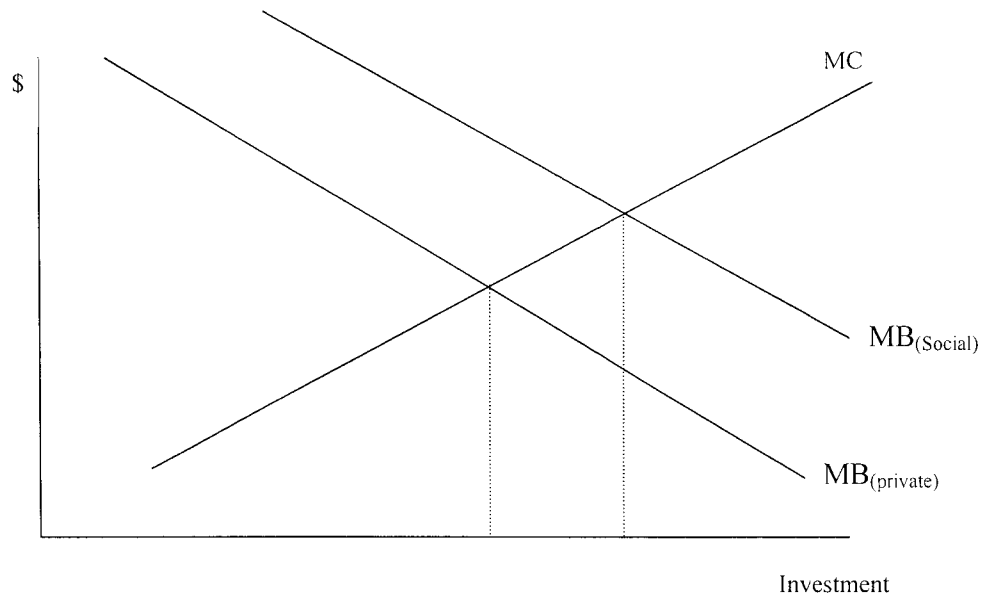
- Whether they would still consider investing (yes or no);
- What their required capitalization rates and discount rate would be under these conditions;
- What their expected holding period would be;
- Whether these responses would already take into account a purchase price lowered by the expected amount of clean-up cost.

The focus of the survey is to elicit hurdle rates for clean versus contaminated properties. A return rate of nearly 20% provided a large and varied sample for data analysis. The full survey instrument is featured in the Appendix.

As suggested previously the clean up cost should be shared by those who benefit directly from the clean up. However the neighborhood benefits may extend beyond the impact of the environmentally damaged site. For example, the city will benefit in terms of increased tax revenue from a new establishment (given new sales are generated), larger income tax revenue from previously unemployed resources, and if property values are assessed correctly increase tax revenue will result. This implies a role for the local municipality to contribute a significant amount in return for their stream of benefits in contrast to a one time increase in housing values.

The cost of this brownfield risk either real or perceived is born entirely by the developer. This increases the wedge between private and social incentives of development in these struggling areas. It is a private hurdle problem with positive social spillovers.

The composite effects of brownfield redevelopment in such contexts can be summarized using a typical marginal benefit/marginal cost analysis. The social benefits to society, through neighborhood spillovers for example, are greater than the private benefits and thus underproduction or underinvestment occurs. This is show graphically below:



In order to achieve a greater amount of investment in these areas some incentives may be needed to motivate private investment. However, before incentives are issued policy makers must understand the risks and stigmas that are associated with these properties, with private returns being directly contrasted with social returns of such development efforts.

Section 3.5 Key Survey Results

A total of 155 surveys were returned, thus a response rate of 17.2%. Of these, 149 contained sufficient basic information to be maintained in the database used for analysis. Not all of these respondents answered all questions, so more restricted samples served as the basis for analyses involving certain questions.

When examining the results of the survey, t-tests were run to determine statistical difference between the means of clean and contaminated properties. The test between clean and gasoline, dry cleaning, and solvents produced t stats of -5.48, -4.62, and -5.23 respectively. All were significant at the one percent level. Samples of these tests are listed in the appendix.

A brief overview of the survey results is given in Table 3 below

Table 3

| | If the property is CLEAN | If there is a GASOLINE contamination problem | If there is a DRY CLEANING contamination problem | If there is a DEGREASING/SOLVENT contamination problem |
|---|--------------------------|--|--|--|
| Would you still consider investing? | N/A | 98 Yes 37 No | 66 Yes 64 No | 70 Yes 64 No |
| Your overall cap rate | 10.23% | 12.51% | 12.83% | 13.19% |
| Your reversion/terminal cap rate | 10.95% | 12.97% | 12.84% | 13.49% |
| The discount rate you would apply | 10.28% | 15.74% | 17.41% | 16.78% |
| Investment holding period? | 9.11 years | 7.42 years | 8.07 years | 8.03 years |
| In addition to the above, Would you also deduct the cleanup costs directly from the resulting purchase price? | N/A | 98 Yes 5 No | 76 Yes 5 No | 79 Yes 5 No |

A full report can be found at the Center for Research on the Colorado Economy⁴. When examining how investors evaluate property it is helpful to define terms such as the different cap rates. To determine the value of a property buyers use two related methods: direct capitalization or discounted cash flow. Both use a rate of return to discount cash flows to present value which is what I use for a hurdle rate in my analysis. A basic assumption of both methods is that real estate is purchased then leased out to a tenant at the prevailing market rent. This creates a flow of income to the owner much like the annual return to a bank deposit.

Direct capitalization is a fairly simple approach and is often used for smaller investments where income streams are steady and predictable. An ‘overall capitalization’ rate is applied to a single year’s income to calculate the value. To determine value of the land Income is placed in the numerator, overall capitalization rate is placed in the denominator, and the resulting division produces a value for the property.

Discounted cash flow is a bit more complex but still reasonably straight forward. This method is used often for larger investments and properties with multiple tenants and/or uneven annual cash flows. Income flows received in the future are discounted to present value using a discount rate to equate the properties value. However, this technique considers the sale, or reversion, of the property at the end of the hold period. Typical hold periods for real estate are ten years⁵. Therefore to get the present value of a property ten years of income must be discounted as well as the revenue from the sale of the asset in following year. To estimate the sale value a capitalization rate is applied to the ‘11th’ year income estimating the value of the property in year 10.

⁴ <http://www.colostate.edu/programs/CRCE/projects-pubs/envir-nr/final-report.pdf>

⁵ Development Research Partners

Given the two pricing methods above should be closely related, that is direct capitalization should embody all the assumptions of the discounted cash flow method. The reality is these techniques are often used depending on property types, size, market, etc. Therefore inclusion of the specific property types in the survey allows for clean comparisons of the responses.

Even when clean-up costs are netted out, a return on risk “premium” is still required for contaminated properties. In comparing a clean versus “dirty” property the addition to the cap rate required on a contaminated site reached 228 basis points for gasoline, 260 basis points for dry cleaning, and almost 300 basis points for solvent contaminations. This represents a significant hurdle to the investor especially during a time of lower economic activity and tighter margins. Sub-sample analysis shows that there is no measurable difference between the rate-of-return differential required by those who develop properties into residential uses, and those who develop them into nonresidential uses.

Respondents are more willing to consider a gasoline problem than a dry-cleaning or solvent problem. Gasoline contaminants have a lower holding period and overall rate as compared to the other contaminants.

In addition to the larger return rates required on these properties even after cleanup costs are deducted, many investors simply will not acquire these properties. For gasoline contaminants over 27% of the market drops out of the bidding. The dropout rates for dry cleaning and other solvents are both over 47%. These properties not only face a larger return requirements but the market itself has shrunk by the above percentages.

In addition to the larger return rates and market retraction, contaminated properties face a depressed property value. When comparing price per square foot a clean property is valued at fifty nine dollars per square foot while a comparable contaminated property is valued at only forty eight dollars per square foot. This is a significant value reduction of 19%. When coupled with higher returns and a thinning market the contaminated sites are a very problematic property.

The conclusion is there is a premium on the rate of return required by private decision makers considering redevelopment of brownfield properties. This premium is generally at least 2 percent and may increase or vary depending on the contaminant type. This premium seems to prevail even when full cleanup costs are known by the developer and included in the return. Therefore, the premium appears to be generated by additional factors that do not represent the true resource costs, namely “stigma” elements associated with contamination and previous contamination. The stigma may develop from undefined perceived risk that is above normal cost risk, perhaps from poor information about liabilities as well as the uncertainty regarding the ultimate resale value of the property.

When developing in an urban area there are unique challenges and opportunities. Brownfields are an example of these obstacles and have the potential for significant positive cleanup effects. The obstacles are largely borne by the developer or entrepreneur as shown by the wedge in private investment. However, there exists significant opportunities for communities to develop these properties with multiple levels of benefits from an increased own property value, increased revenue for the area, and lower opportunity costs that further raise the social gains from development. In addition neighboring properties can also be impacted by the cleanup of the stigmatized property.

This impact is examined in the subsequent chapter. Overall these calculations can be incorporated into a benefit cost analysis to prioritize sites for development and dollars allocated to those properties.

CHAPTER IV SPATIAL DEPENDENCE IN ECONOMETRIC MODELS

Section 4.1 Basics of spatial influence

This chapter examines the spatial impact of environmentally hazardous sites on local housing values. While much work has been done on large sites there has been a limited amount done to address smaller sites. The spatial analysis that has been done uses techniques that may not capture the full effect of these contaminated sites. In this chapter I will introduce an alternative approach for spatial estimation that allows for an infinitely divisible spatial impact. This new approach will improve the spatial analysis in this and other econometric models.

Space influences many social and economic choices we make every day. People try for the close parking space at the store; homes next to the golf course sell for higher prices, large cities formed by the coast and major waterways, even on campus the closer you are to the student center may influence your decision to purchase a soda from the machine. All these interdependences are summed up in Tobler's *first law of geography*, which states, "Everything is related to everything else, but near things are more related than distance things." (Tobler 1979)

To relate this to spatial econometrics it is helpful to distinguish between the two types of spatial influence. The first is spatial dependence or spatial autocorrelation which implies a relation of distance. This can be extended beyond the physical spatial distance and can include such as political distance for example New Mexico is often referred to as a "two call or person state." Meaning it usually takes someone two calls or two people for

them to connect to a governing official. This idea of political space and social networks opens a larger area for research. However, this dissertation will only focus on the specific spatial relations of physical property. Much like people will travel further to shop at a store with low crime, or pollution creating a pattern over space.

To include this spatial dependence in our economic analysis may not be as easy as it might seem. Data often comes separated by arbitrary dividers such as census tracts, zip codes, state boundaries, counties, etc. These borders are arbitrary and may have been formed because of political reasons, technological limitations, war, transportation routes or some other random event. These relations have long since dissolved in our ever changing economy yet the borders cannot be redrawn every time a change occurs. The traditional ordinary least squares estimations do not account for these relationships and results in biased results (Anselin, 1998). As Anselin points out “Spatial dependence can be caused by a variety of measurement problems often encountered in applied work.” Therefore we must figure out a way to incorporate these spatial autocorrelation effects into our analysis.

Section 4.2 Spatial Effects

Consider a typical linear regression model in the form

$$y = X\beta + \varepsilon$$

in the presence of spatial correlation the estimators for beta (β) can become inconsistent and biased or inefficient. The impact of the beta depends on the type of spatial dependence. For spatial autocorrelation betas are biased and inconsistent. This is very similar to the simultaneity problem. Simultaneity is a specific type of endogeneity

problem in which the explanatory variable is jointly determined with the dependent variable. That is the spatial dependence enters the equation as follows

$$y_i = f(y_j) + X\beta + \varepsilon.$$

In the real estate market this seems almost obvious to say your home price is directly affected by your neighbors' price. Many home sellers and buyers will survey the local market to determine the optimal selling/bidding price for their home of interest. If this interaction is not modeled in our analysis then there is a violation of the Gauss-Markov Theorem. Spatial autocorrelation is formally expressed as follows:

$$\text{Cov}[y_i, y_j] \neq 0 \quad \forall i \neq j$$

This is comparable to the time series lagged variable or autoregressive process but the main difference is space has multiple lagged relationships⁶.

A more general equation can be used to express spatial influence. Where y is a $n \times 1$ vector of cross sectional dependent variables, X is a $n \times k$ matrix of explanatory variables, W_1 and W_2 are $n \times n$ spatial weight matrices.

$$\begin{aligned} y &= \rho W_1 y + X\beta + \mu \\ \mu &= \lambda W_2 \mu + \varepsilon \\ \varepsilon &\sim N(0, \sigma^2 I_n) \end{aligned}$$

Setting W_1 and $W_2 = 0$ produces the classical linear regression model.

⁶ For a complete discussion of the difference see Anselin and Bera (1998)

$$y = X\beta + \varepsilon$$

$$\varepsilon \sim N(0, \sigma^2 I_n)$$

Setting $W_1 = 0$ produces a spatial error model with spatial autocorrelation in the error terms.

$$y = X\beta + \mu$$

$$\mu = \lambda W_2 \mu + \varepsilon$$

$$\varepsilon \sim N(0, \sigma^2 I_n)$$

Setting $W_2 = 0$ will produce a mixed regressive spatial-autoregressive model.

$$y = \rho W_1 y + X\beta + \varepsilon$$

$$\varepsilon \sim N(0, \sigma^2 I_n)$$

You may also weight the explanatory variables as in the spatial Durbin model below:

$$y = \alpha + X\beta_1 + WX\beta_2 + \varepsilon$$

$$\varepsilon \sim N(0, \sigma^2 I_n)$$

If we set W_1 and $X = 0$ this produces a first-order spatial autoregressive model shown above:

$$y = \rho W_1 y + \varepsilon$$

$$\varepsilon \sim N(0, \sigma^2 I_n)$$

This model is analogous to the time series model of $y = \rho y_{t-1} + \varepsilon$ where variation in y is dependent solely on past period observations. The two models differ in the sense that spatial “lags” can go in multiple directions as apposed to the single direction of time lags. The introduction of a time lag into the spatial models is possible and increases the complexity of the analysis introducing spatial heterogeneity as well as time-wise heterogeneity. For my analysis I will omit the space-time models.

There are many more types of spatial regression as well as spatial weighting matrices. For spatial autoregressive significance is straightforward in testing the rho parameter. For spatial autocorrelation there exist three main tests for the error terms. The Wald, Likelihood Ratio, and Lagrange Multiplier are relatively easy to implement but have some complications when interpreting the results. A discussion on spatial autocorrelation of the error terms is found in Anselin Chapter 6⁷.

The attempt to quantify or correct for this relationship can be done in many ways but a common approach is the use of weighting matrices. A simple nxn matrix of influence for each observation is widely used for its relative simplicity. Consider a linear city block with four homes side by side. To create a matrix of influence we would need to generate a 4x4 matrix for our data set. Elements in this matrix will be non-stochastic given they are based on the geographic coordinates. The symmetric matrix would contain values of 1 for every observation that has a neighbor and 0 otherwise. The resulting matrix is as follows:

$$M = \begin{pmatrix} 0 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{pmatrix}$$

The matrix M is a 4x4 matrix with row one representing the observations for our first home. The columns represent our observations as well. Therefore a one placed in row one column two means home number 1 is influenced by its neighbor home number two. Home number three and four are not a neighbor so zeros are places in those spots.

⁷ Pg 101-105

Following with row two, homes one and three are neighbors to home number 2 so there are ones in the corresponding elements. The diagonal is purposely set to zero to eliminate the influence of a home on itself. In our regression analysis this eliminates a home from predicting its own value. Often the matrix is normalized or transformed to have row sums to one. This produces a “standardized first order” contiguity matrix I call S.

$$S = \begin{pmatrix} 0 & 1 & 0 & 0 \\ .5 & 0 & .5 & 0 \\ 0 & .5 & 0 & .5 \\ 0 & 0 & 1 & 0 \end{pmatrix}$$

The reasoning behind this standardization can be seen when we take some characteristic of our four homes (y) and multiply them by the standardized matrix S. to produce the following new variable that is a mean influence of these contiguous variables.

$$Y^* = \begin{pmatrix} 0 & 1 & 0 & 0 \\ .5 & 0 & .5 & 0 \\ 0 & .5 & 0 & .5 \\ 0 & 0 & 1 & 0 \end{pmatrix} * \begin{pmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \end{pmatrix}$$

$$Y^* = \begin{pmatrix} y_2 \\ .5y_1 + .5y_3 \\ .5y_2 + .5y_4 \\ y_3 \end{pmatrix}$$

This is one way of expressing the spatial dependence addressed above in the equation $y_i = f(y_j) + X\beta + \varepsilon$ where $i \neq j$. We can now take the variable we created above and use it as an explanatory variable in a linear regression model to explain the variation in space across our sample. This spatial weighting matrix can be considered a spatial smoother or evening out the lag.

The neighbor approach is not the only option for the weighting matrix. Nearest neighbors, distance decay, and other types of contiguity are also options for assigning spatial specifications. Although this seems to make the choice arbitrary but some make more economic sense than others given the data used for analysis. The weights should also be exogenous to the model to avoid identification problems (Manski 1993).

The selling price of a residence (Y) is a function of observable characteristics (area, age, bedrooms...) and some unobservable characteristics creating a spatial regressive relation.

$$\begin{aligned} (I_n - \rho S)y &= X\beta + \varepsilon \\ y &= \rho S y + X\beta + \varepsilon \end{aligned}$$

Rho becomes a regression parameter to be estimated and ε is the stochastic disturbance in the relationship. The estimate of rho would be the spatial dependence exhibited by our data. The explanatory variables are represented by $X\beta$ such as beds, baths, and square feet in our housing example.

Section 4.3 Other Weight Schemes

With the above weighting scheme defining the weight matrix has an unlimited amount of options in terms of distance, direction, number of lags, and even number of

weight matrices to include. Social interactions can also be added to the spatial weight matrix to create a social weighting scheme. In addition to spatial weighting in a spatial autoregressive model as shown in the previous section other options exist to account for the 'missing' variable problem.

Spatial expansion was first introduced by Casetti (1972) to deal with spatial heterogeneity by allowing the parameters of the model to vary with the spatial location of the data. One problem with the original Casetti model is the introduction of a heteroscedastic relationship unless the expansion relationship is exact. To account for this problem Casetti (1982) and Casetti and Can (1998) introduced Drift Analysis of Regression Parameters or DRAP. The Casetti model(s) works under the assumption that the parameters vary as a function of the latitude and longitude coordinates. Therefore a central point or a fixed location is determined and the parameters are allowed to change with respect to this location. This option is attractive if we are measuring the decay of the inner city as described in the beginning of this dissertation. A city center or downtown could be used and the decay of influence modeled. If a city had only one environmentally damaged site this approach would be appealing to a researcher. With multiple brownfield sites, as is the case in most areas, choosing just one point of influence is impractical.

Cliff and Ord (1975) introduce space and time estimations to improve regional forecasting. Using the data provided in Casetti and Semple (1969) Cliff and Ord examine autoregressive, moving average and regression forecasting models applied to space-time data sets. This approach is of interest when evaluating home sales however a larger data set across many years is needed to complete this type of estimation.

Non-parametric locally linear models and geographically weighted regressions were introduced recently by McMillen (1996, 1997) and Brunson, Fotheringham and Charlton (1996) respectfully. These models rely on the use of distance-weighted sub-samples or the data to create locally linear regression estimates for every point across the sample space. That is each set of parameter estimates is based on a smaller neighboring data points. The rate of decay or weighting function used again becomes capricious. McMillen (1998) suggest a tri-cubed function, Brunson, Fotheringham, and Charlton introduce a ‘bandwidth’ decay parameter, and a Gaussian function can also be used. This approach has some appealing attributes for spatial economics however there are some problems. A lack of independence between estimates for each location may produce invalid parameter estimates, outliers also become more of a problem in this method. A Bayesian approach can be used to correct for some of these problems.

Given all the options available to a researcher deciding on the appropriate method of modeling spatial dependence can be a daunting task. All these approaches again are trying to capture a “missing variable” that biases our results. Before arbitrarily selecting from all the alternative options theoretical reasoning should be used to find the appropriate weighting method. The next sections describe my reasoning in creating unique spatial variables to model spatial dependence in my data.

Section 4.4 Creation of Missing Spatial Variables

There are two approaches to spatial dependence, an econometric approach and a statistical approach. Spatial econometrics begins with theory a priori, imposes structure into formal model for statistical analysis. A second approach is spatial statistics which

starts with data and infers dependence using correlations statistics, autocorrelation approaches and like tools. As econometricians we must start with theory and work from there. In that sense I will describe my approach to improving the traditional hedonic model.

In all spatial models the goal is to account for missing variables. If the true hedonic model is correctly specified it would require no spatial weighting matrix since that variable would already be included in the explanatory variables. In examining the housing market the spatial component most affecting my own home value is the value of surrounding homes. In this sense these surrounding home prices also incorporate local community characteristics such as homeowner associations, shared amenities, and often common characteristics. Thus that is the motivation behind the SAR model used in MATLAB. A weakness of the SAR model is the impact of close and far neighbors cannot easily be separated given the rho for our weighting matrix is constant. This next section will go about the development of statistically estimated spatial dependence variables.

The idea that home prices are affected by neighboring prices is not new to the real-estate market. It is often said you never want to purchase the largest home on the block due to the negative influence of smaller homes. In addition anyone purchasing homes is often presented with a list of “comps” or similar homes in their neighborhood and their sales price. The price is not the only factor that could be influencing neighboring home amenities may also influence the prices. However, it is often the case most homes in an area follow similar floor plans and differ only slightly on amenities. If the amenities differ it will be reflected in the home price and therefore enter the

relationship indirectly. Therefore my spatial variable of influence will be the neighboring home values.

An average of surrounding home prices is a logical choice for my explanatory variable. To set it apart from a SAR model in MATLAB I have the ability to choose a variety of distances to compute this variable. For example, I can take all the home values within a $\frac{1}{4}$ mile of the observation, or $\frac{1}{2}$ mile, 1 mile, to an infinite number of possibilities. In addition I may examine the homes that reside $\frac{1}{4}$ to $\frac{1}{2}$ miles away from the observation, or $\frac{1}{2}$ to $\frac{3}{4}$, and so on. Each variable created can be statistically tested for significance. Creation of these variables seems trivial but actually includes some creative programming skills.

My first attempt at creating these variables was to use a GIS program to calculate the variables. There are many GIS programs that can be used to create buffer zones around observations and produce graphical representations of data as well as export that data for analysis. Most widely used is ArcMap a product of ESRI. The process of creating these variables was extremely slow and tedious in this program since it was not intended to manipulate data in this fashion. As mentioned earlier buffer zones or saturation indexes are not the optimal variable choice. In addition, other complications arise when using different projections and coordinates systems to generate the buffer zones. Given these difficulties another method to construct these variables was needed.

Excel combined with a visual basic (VB) compiler creates a very powerful tool to edit and manipulate small datasets⁸. Using VB I created a macro to extract the average housing prices of homes within a specific distance. This distance was altered several different ways to obtain a range of values and options for my spatial variables. A sample

⁸ Excel 2003 worksheets are limited to 65,536 rows by 256 columns.

of this script is included in the appendix the entire script is over 500 hundred lines long and will be provided upon request. The benefit of running this script outside of MATLAB is speed given the relative quickness of a compiler language versus MATLAB. In addition memory usage is much less using Visual Basic. Even with these efficiencies the process of creating each variable with over five thousand observations took between thirty to forty-five minutes to complete.

Section 4.5 Data

The focus area for estimation is the city of Greeley, Colorado a city with just under 100,000 residents. Large employers in the area include Hewlett-Packard and ConAgra's Beef Company but many people also commute to the larger employment centers of Denver and Fort Collins. Local and national resources were employed in collecting data.

Brownfield data was compiled from multiple EPA Hazard data sources including: EPA EnviroMapper (LandView), HUD's Environmental Mapper, Environmental Scorecard, and EPA's Landfill. The data sources above are all derived from the EPA's hazardous data set and are included in the EPA's Brownfield tools site. Each source is publicly available and most have websites where the user can quickly map out hazards in their area. When conducting initial data source searches all sources eventually pointed back to the EPA. The sites used by development agents describe the typical boundary set of information researched on each property. Inquiries made to development agents produced a list of informational sites. These sites were researched and then traced back to their data sources. In addition a web search was conducted as well as a series of other

sources were investigated. After consolidating the multiple data options the 4 listed above were chosen for the following reasons:

1. EPA data source (EPA is responsible for tracking these properties)
2. Free public access- all data provided is free of charge and easily accessible
3. Above data sources are among the first checked by development agents and financial institutions conduction a Phase I assessment of the property.

The hazardous property data may also be broken down by type of contaminant. This may be used to estimate the effect of different types of pollutants or different types of discharges. However, there have been studies showing people are not concerned with the type of contaminant only the fact that there is a contaminant (Kohlhase 1991). Perhaps further research may be used to estimate the different effects of different types of brownfield contaminates.

Housing data was obtained from the Weld County assessor on housing sales and characteristics over a five year period. The data set was scaled down to only include sales of homes from 1998-2003. If a home sold multiple times the final sale listed was used. The reason for dropping multiple sales becomes apparent when examining the weighting matrices used in spatial econometric estimation these data were also left out in my regression to preserve consistency. When examining a weighting matrix based on geographic coordinates having two observations with the same coordinates creates consistency problems.

The data obtained is from multiple time periods which can also lead to estimation problems. To avoid the space-time distortions all home values were adjusted using the Denver-Boulder-Greeley CPI⁹.

Which variables to include in the regression is always a concern when estimating a hedonic model. For my estimation the basic characteristics were used such as bedrooms, baths, area, age, central air, and fireplace. Many other variables were dropped including stories, all quality variables, carport, out building, porch, and others. In talking with local assessors many of these variables are often only loosely tracked if at all. This was apparent when I examined the condition variables contained almost all homes listed as typical (5,531). In addition the quality variables were distributed similarly. Which suggest that all 5,632 homes are of similar quality and condition or the assessor has opted not to track this variable very closely. In many cases quality variables are hard to track and susceptible to different view on quality. In my recent home purchase I was able to write my own idea of quality of my home for the assessor which was amusing considering I had never seen the house previous to filling out the assessor forms. Considering these issues the data was paired down to include only the most common items used to assess home values and records containing complete data.

Brownfield data was compiled to include all items that could fall under the definition of brownfields. Companies such as Platte Chemical Company fall under multiple categories of hazards including toxic releases and hazardous waste generators so multiple listings were deleted. Additional brownfields were dropped from the list such as a small burrito restaurant that had a toxic release. Often times any spill or accident will

⁹ Data are published for 12 metropolitan areas on a semiannual basis. These indexes, which refer to the arithmetic average for the 6-month periods from January through June and July through December. <http://www.bls.gov>

cause a report to be generated and your business to be present on the hazards lists. In researching my own hometown I found the local church I attended on the hazards lists! This was due to a small spill of cleaning solvent in the kitchen. For this reason a closer filtering of the list was needed.

A regression with all brownfield sites was initially run with all brownfields included (Appendix Figure 4.1). Some of the smaller and less hazardous sites such as Burris Company Inc, an optics store selling a variety of scopes, were dropped from the list. Remaining companies were Platte Chemical Company, Monfort Lamb Incorporated, Hewlett-Packard Company, and Lafarge.

Platte Chemical Company is primarily a pesticide producer used by local and national agriculture industries. Platte Chemical Company has had previous sanctions imposed by the EPA regarding mishandling of hazardous waste and lack of disclosure under the Emergency Planning and Community Right-to-Know Act.¹⁰ However, through recent "Chemsweep" programs the company has aided in cleaning up its perceived and actual hazardous impact on the community.

Monfort Lamb Incorporated was purchased in 1987 by ConAgra's Beef Company but the unification under the ConAgra's name did not happen until December 1999. However, many of the environmental hazards report as well as some citizens of Greeley have not yet adapted to the new name. . Their role in Greeley began primarily a meat processing plant in the early 60's and built a lamb plant next door in the late 80's. Throughout the last four decades Conagra has been a major employer in the Weld county area. However, the processing of livestock does not come without a cost. The area around

¹⁰ <http://www.epa.gov/region08/news/news98.pdf>

the plant has increased traffic and the plant itself emits toxic air releases which can be carried great distances given certain wind conditions.

HP is a multinational company with offices throughout the world. The Greeley location is primarily responsible for digital imaging. For most this is the testing and production of scanners and like devices. Although they handle several hazardous chemicals during the day to day operations HP in Greeley has not encountered a major spill or damage event. However, simply handling the hazardous chemicals places this company on the EPA hazards list.

Lafarge is a large construction contractor dealing with masonry as well as many road construction projects. The release by Lafarge includes discharges to air and water according to the EPA reports. Included in the EPA notes there are potential for uncontrolled emission from this site. While the term uncontrolled sounds rather scary it is impossible to avoid given the materials handled by Lafarge. Consider pouring out a bag of concrete without releasing any dust particles into the air. For Lafarge these emissions are below 100 tons per year.

The paired down data set was double checked and ready for statistical estimations. The follow section details the resulting impacts of brownfields.

Section 4.6 Results

The Matlab Spatial Autoregressive function (SAR) is represented by the following equation:

$$Y = \rho WY + X\beta + \varepsilon \quad (1)$$

The variable Y is vector of housing prices and X is a matrix of housing characteristics such as bedrooms, bathrooms, etc. and β is a vector of coefficients to be estimated. The matrix W , which incorporates the likely spatial relationship between neighboring housing prices, represents the spatial component.

When the parameter ρ is estimated to be significant, then it is interpreted that the entire W matrix is significant. A limitation of this specification is that the impact of subsets of the spatial components of W cannot be isolated to determine whether one part of the matrix is more important than another component. The problem is that all the homes that are specified in W may not evenly contribute to the significance of ρ . It would be a very difficult task to determine which houses in the W matrix were the important components. As an example, one could vary the nearest neighbor from one to up to say 50, and determine where the significance lies, but this would be an arduous process. In addition a multitude of contiguity matrices may be estimated reflecting slightly different spatial relationships.

Instead, my straightforward approach, allows for the unique estimation of a large number of spatial components. The spatial variables created represent the average price of home within $1/8$ of a mile around each home in the data set. Then a similar average that ranged from $1/8$ to $1/4$ of a mile around each house was calculated. This process continued until covered distances up to two miles from each house. The specification can then be written as the following:

$$Y = \alpha_0 + \alpha_1 Y_1 + \alpha_2 Y_2 + \alpha_3 Y_3 + \dots + \alpha_8 Y_8 + X\beta + \varepsilon, \quad (2)$$

Where Y_1 represents the average value of houses sold up to a distance of one-eighth of a mile around each house and Y_2 represents the average value of houses from one-eighth to one-quarter of a mile around each house. Y_8 represents distances from $7/8$ of a mile to one mile. In this way one can estimate the unique contributions of each spatial component can be estimated using OLS, whereas in the SAR technique, specific algorithms need to be constructed to do the estimation.

Then I estimated equations (1) and (2) for the years 1998-2003 using a semi-log transformation of the data. As mentioned previously I included the usual housing characteristics such age, size, bathrooms, bedrooms and in addition included distances to the brownfields. Table 4-1 presents the estimates of the spatial variables for the SAR approach and my technique. The weighting matrix used in the SAR approach was the five nearest neighbors weighting scheme. I did alter this specification and did not find any appreciable difference in the results below. Standard errors are reported below the coefficients and all are significant at the five percent level unless otherwise noted.

Table 4.1 Regression Results

| | Spatial Autoregressive | | | Widner Model | | |
|-------------------------|------------------------|---------|------------|--------------|---------|------------|
| | Coefficient | T-Stat | Std. Error | Coefficient | T-Stat | Std. Error |
| Constant | 9.567264 | -48.28 | 0.198 | 10.80625 | -151.35 | -0.0714 |
| Age | -0.00213 | 23.23 | 0.00009 | -0.00203 | 21.57 | -9.4E-05 |
| Area | 0.000011 | -10.00 | 0.000001 | 0.000011 | -20.48 | -5.4E-07 |
| Beds | 0.033482 | -7.11 | 0.0047 | 0.03378 | -6.72 | -0.00502 |
| Bath | 0.223207 | -354.86 | 0.00063 | 0.219249 | -46.20 | -0.00475 |
| Platte | -0.14368 | 11.068 | 0.01298 | -0.07761 | 2.44 | -0.03178 |
| Monfort | 0.112801 | -4.14 | 0.02721 | 0.062129 | -1.90 | -0.03274 |
| HP | -0.02187 | 1.62 | 0.01347 | -0.01207 | 1.37 | -0.00884 |
| LaFarge | 0.019878 | -4.00 | 0.00496 | 0.02165 | -4.01 | -0.0054 |
| Rho | 0.148992 | -5.82 | 0.0256 | | n/a | |
| Average Price 1/8 | | n/a | | 0.00021 | -9.38 | -2.2E-05 |
| Average Price 1/8-1/4 | | n/a | | 0.0001 | -3.39 | -3E-05 |
| Average Price 1/4 - 1/2 | | n/a | | 0.0001 | -2.62 | -3.8E-05 |
| R-Squared-Adjusted | | | 0.5254 | | | 0.5386 |

The coefficients for housing characteristics are similar in both models however, the impact of the brownfields changes significantly between the models. One would expect the impact of the brownfield distance to have a positive sign. That is, a larger distance away, the higher your home value. In the results about two sites produced negative and significant coefficients. First the Platte Chemical Company is located near the University of Northern Colorado (UNC) which is a major employer in the area. In addition to employment there are many positive benefits of being close to the campus especially in a rural community. Therefore this sign may be impacted by the presence of

UNC. Second is the Hewlett-Packard Company another major employer in the region. Again the benefits of being close to your employment center may offset the negative impact of environmental effects. Also, HP is close to a major highway that provides access to other employment centers such as Denver and Fort Collins as well as many recreational excursions. These offsetting factors are most likely the reason for the Hewlett Packard variable being insignificant.

The spatial variables under the Widner technique are all significant and decreasing in their impact as you get further away from the property. This is in line with what theory would predict. The variables beyond ½ mile were insignificant and removed from the equation. The HP coefficient is significant at the fifteen percent level in the Matlab estimation while it drops to the twenty percent level under the Widner estimation. This may be due to the inclusion of my spatial variables since they are setup to capture those same effects. The spatial variables I created also capture other things such as local benefits of a nearby park, lake, store, etc... It may also account for items such as homeowners associations, local taxes¹¹, and other community specific characteristics.

Inclusion of these spatial variables has increase the explanatory power of the equation. As shown in the increase adjusted R² value. This suggests these variables are indeed capturing some missing housing characteristics that impact the price.

Section 4.7 Granger and Newbold Test

To compare the two models is not a straight forward task. The inclusion of the weighting matrix complicates coefficient comparisons. Therefore the implementation of alternative techniques such as the Granger and Newbold (1986) test is used to determine

¹¹ Example Mello-Roos tax in California has an impact on selling prices

which model is superior in terms of explaining movements in housing prices. Granger and Newbold suggest that the following regression be used in evaluating competing structural models:¹²

$$e_i^W - e_i^S = b_0 + b_1(e_i^W + e_i^S) + u_i, \quad (3)$$

where e_i^W is the estimated residual from equation (2) and e_i^S is the estimated residual from equation (1). A negative coefficient on b_1 implies as total unexplained variation rises in both models ($e_i^W + e_i^S$) the increased unexplained variation in the Widner model is less than that in the SAR model. This indicates my specification better fits the data. A $b_1 > 0$ would indicate the SAR specification as superior.

The estimate of equation (3) produced a negative beta significant at the five percent level, which suggests that the Widner model is superior in forecasting changes in housing prices. The alternative specification of the Widner model allows for greater individual variation in the spatial component, which contributes to a better fit of the data.

Section 4.8 Summary

The objective of this chapter was to determine the spatial influence of brownfields on property values. Much work has been done in determining the effect of large single superfund waste site yet there is little work concerning smaller brownfields. Brownfields are unique and challenging since they can exist on a single lot or a combination of multiple lots. Current and former uses range from gas stations to hospitals and many

¹² Clapp and Giaccotto use this approach to evaluate competing housing price models.

different types of business in-between. Thus the estimation of these effects proved to be a daunting task.

First there were many types of spatial influence to examine such as spatial autoregressive models, spatial error models, Casetti models, and geographically weighted models. Within each of these numerous weighting schemes can be used and often times significant results will emerge with multiple weighting matrices. In estimating spatial equations a limitation of current spatial weighting schemes was found. The limit is not in the spatial theory yet the weakness is in the current software applications used to construct weighting matrices. The limits of direction and intensity of influence reduce the forecasting accuracy of the spatial autoregressive model.

The Widner approach of introducing spatial variables consisting of surrounding home values strengthened the explanatory value of current hedonic models. By using over five thousand observations of home sales in Greeley, Colorado a significant impact on housing values was estimated. Future software packages may have the variability to adjust weighting schemes to include the characteristics of my spatial variables used in this chapter.

CHAPTER 5 SUMMARY

5.1 Summary and Conclusions

In the last decade a large amount of attention has been focused on the struggling areas of our cities. Much of the initial spotlight was on the historic downtown districts and their transformation back to a desirable location to live and work. This has been successful in many areas but it has created a “donut” of development in our urban areas. Now other neighborhoods are facing capital flight, vacant buildings, and reduced retail activity. To continue the revival attention must be directed at the areas of highest priority. Determining the priority is often a daunting task for public officials and local investors.

This dissertation has outlined steps in determining overlooked areas in the inner city and benefits from developing these areas. Beginning with the first section struggling socioeconomic areas were identified. The outflow of retail spending was identified and an opportunity for public involvement was introduced. Without some public assistance the information gaps and stagnation will persist.

The retail leakages chapter began with identifying struggling areas using socioeconomic indicators. After the identification process was complete specific needs of the neighborhood were then addressed. Specifically in Denver the lack of retail establishments to serve the communities was found. Even though opportunities for significant profits exist without the proper information and support stagnation will continue in these neighborhoods.

In addition to the economic conditions above, these areas also face environmental challenges. In the late 90's the term brownfield was developed to describe the environmentally damaged sites throughout our cities. Brownfields have now become the focal point of many local officials as they try to cleanup the inner city. However, given the uniqueness and vast number of these sites public funds alone cannot solve the problems.

Chapter 3 introduced the properties associated with brownfields and illustrated the location of these properties throughout the city. The range of current and former uses leads to different types of contaminants on the property. The cleaning up of these sites takes knowledge of these contaminants and a willingness to invest in the property. This chapter found that even with the cleanup cost figured into the equation investors placed an additional premia on the contaminated properties. This premia creates an inefficiency in the market and reduces the net benefits available to society. Aside from the properties' social benefits there would also be external spillover effects to the adjoining properties.

Chapter 4 examined the spatial effects of these environmentally damaged sites on neighboring property values. In the process of finding significant negative effects from brownfields an improved estimation technique was developed. The inclusion of spatial variables in a traditional hedonic model was tested to have increased forecasting ability when compared to the traditional spatial autoregressive model.

Together these chapters provide some rationale for public involvement alongside private investors to combat stagnation. Without a combined effort each entity will likely fail in its rebuilding attempts. Given the joint interest in success it seems only logical that

these institutions unite efforts and promote the opportunities that exist in our nations cities.

BIBLIOGRAPHY

Akerlof, George (1970) "The Market for 'Lemons': Quality Uncertainty and the Market Mechanism," *The Quarterly Journal of Economics*, 84, 488-500.

Arrow, Kenneth J. and Robert C. Lind (1970) "Uncertainty and the Evaluation of Public Investment Decisions," *American Economic Review*, 60:3, 364-378.

Bartik, Timothy (1990) A The market failure approach to regional economic policy, @ *Economic Development Quarterly*, 4:4, 361-370.

Brundson, C. A. S. Fotheringham, and M. Charlton. 1996. "Geographically weighted regression: a method for exploring spatial nonstationarity," *Geographical Analysis*, Vol. 28, pp. 281-298.

The Boston Consulting Group and The Initiative for a Competitive Inner City (BCC & ICIC) (1998). *The Business Case for Pursuing Retail Opportunities in the Inner City*. Boston, Massachusetts.

Boyle, Melissa and Katherine Kiel (2001) "A Survey of House Price Hedonic Studies of the Impact of Environmental Externalities," *Journal of Real Estate Literature*, 9:2, 117-144.

Bradbury, Katherine, Anthony Downs, and Kenneth Small (1982) *Urban decline and the future of American cities*. Washington, DC: Brookings Institution.

Casetti, E., 1972. "Generating Models by the Expansion Method: Applications to Geographic Research", *Geographical Analysis*, Vol. 4, pp. 81-91.

Casetti, E. (1982) "Drift Analysis of Regression Parameters: An Application to the Investigation of Fertility Development Relations", *Modeling and Simulation* 13, Part 3:, pp. 961-66.

Casetti, E. and A. Can (1998) "The Econometric estimation and testing of DARP models." Paper presented at the RSAI meetings, Sante Fe, New Mexico.

Clapp, John M. and Carmelo Giancotto (2002) "Evaluating House Price Forecast," *JRER* Vol. 24:pp. 1-26.

Cliff, A. D. and J. K. Ord (1975) "Space-Time Modelling with an Application to Regional Forecasting." *Transactions of the Institute of British Geographers* No. 64, pp. 119-128.

Consumer Expenditure Survey. Website <http://www.bls.gov/csxhome.htm>, reading from subheading "Two-year tables, cross-tabulated", Metropolitan Statistical Area, Western MSA.

Dixit, Avinash and Robert Pindyck (1994) *Investment Under Uncertainty*. Princeton, NJ: Princeton University Press.

Dymski, Gary (2001) "Can Entrepreneurial Incentives Revitalize the Urban Inner Core? A Spatial Input-Output Approach," *Journal of Economic Issues*, 35:2, 415-422.

The Economic Census. "Retail Trade," which includes SIC explanations and subheadings at <http://www.census.gov/epcd/www/econ97.html>

Environmental Protection Agency

<http://www.epa.gov/region08/sf/shtk/shattuck.html>

Forester, Murray (2000) "Retail's Next Frontier Is Not Overseas," *Chain Store Age*, 76:3, 14.

Freeman, A. Myrick III (1993) *The Measurement of Environmental and Resource Values*. Washington DC: Resources for the Future.

Gawande, Kishore, and Hank Jenkins-Smith (2001) "Nuclear Waste Transport and Residential Property Values: Estimating the Effects of Perceived Risks." *Journal of Environmental Economics and Management* 42(2), p207-233

Granger, C. W. J. and Newbold, P. (1986). *Forecasting Economic Time Series*. San Diego: Academic Press.

Kohlhase, Janet (1991) "The impact of toxic waste sites on housing values" *Journal of Urban Economics*, 30, p1-26

Lang, William W. and Leonard I. Nakamura (1993) "A Model of Redlining," *Journal of Urban Economics*, 33, 223-234.

LeSage, James P. (1998) *Spatial Econometrics* <http://www.spatial-econometrics.com>

Loukaitou-Sideris, Anastasia (2000) "Revisiting Inner-City Strips: A Framework for Community and Economic Development," *Economic Development Quarterly*, 14:2, 165-181.

McMillen, Daniel P. 1996. "One hundred fifty years of land values in Chicago: a nonparametric approach," *Journal of Urban Economics*, Vol. 40, pp. 100-124.

McMillen, Daniel P. and John F. McDonald. (1997) "A Nonparametric Analysis of Employment Density in a Polycentric City," *Journal of Regional Science*, Vol. 37, pp. 591-612.

Michaels and Smith (1990) "Market segmentation and valuing amenities with hedonic methods: The case of hazardous waste sites," *Journal of Urban Economics*, 28 p223-242.

Mills, Edwin S. and Luan Sende Lubuge (1997) "Inner Cities," *The Journal of Economic Literature*, 35:2, 727-756.

Mushinski, David and Stephan Weiler (2002) "A Note on the Geographic Interdependencies of Retail Market Areas," *Journal of Regional Science*, 42:1, 75-86.

Okoruwa, A. Ason, Hugh Nourse, and Joseph V. Terza (1994) "Estimating Sales for Retail Centers: An Application of the Poisson Gravity Model," *The Journal of Real Estate Research*, 9:1, 85-97.

Pace, R. Kelley (1998) "Performing Large Spatial Regressions and Autoregressions." *Economics Letters*, 54(3), p77-99

Porter, Michael (1997) "New Strategies for Inner-City Economic Development," *Economic Development Quarterly*, 11:1.

PricewaterhouseCoopers and The Initiative for a Competitive Inner City (PWC & ICIC) (1999) *The Inner City Shopper: A Strategic Perspective*. Boston, Massachusetts.

Scorsone, Eric and Stephan Weiler (2004) "New Markets as Informational Asymmetries." *Economic Development Quarterly*, 18(3), 303-313.

- Silverstein, Jesse (2001) "Redevelopment Opportunities: 73rd Avenue/Lowell Boulevard Corridor - Westminster, Colorado." Denver: Development Research Partners.
- Stigler, George (1961) "The Economics of Information," *Journal of Political Economy*, 69, 213-225.
- Stiglitz, Joseph E. and Andrew Weiss (1981) "Credit Rationing in Markets with Imperfect Information," *American Economic Review*, 71:3, 393-410.
- Taneja, Sunil (1998) "Inner City Opportunity Knocks: Tapping Into a \$100 Billion Market," *Chain Store Age*, October, 177-180.
- U.S. Department of Housing and Urban Development (HUD) (1999) "New Markets: The Untapped Retail Buying Power in America's Inner Cities." Washington, D.C.: HUD.
- Weiler, Stephan, Jesse Silverstein, Erin Lacey, William Rogers, and Benjamin Widner (2003) "Understanding the Retail Business Potential of Inner Cities," forthcoming *Journal of Economic Issues*.
- Weiler, Stephan, Eric Scorsone, and Madeleine Pullman (2000) "Information Linkages in Local Economic Development," *Growth and Change*, 31:3, 367-384.
- Weiler, Stephan (2000a) "Linking Regional Markets: Information and Market Failure in Local Economic Development," *Economic Development Quarterly*, 14:2, 194-203.
- Weiler, Stephan (2000b) "Pioneers and Settlers in LoDo Denver: Private Risk and Public Benefits in Urban Redevelopment," *Urban Studies*, 37:1, 167-179.
- Wievel, Wim, Joseph Persky, and Daniel Felsenstein (1995). "Are subsidies worth it? How to calculate the costs and benefits of business incentives." *Government Finance Review*, 23-27.
- Zerbe, Richard O., Jr. and Dwight D. Dively (1994) *Benefit-Cost Analysis in Theory and Practice*. New York: HarperCollins.
- Zip Code Business Patterns. Department of Commerce – Census Division. CD-ROM.

APPENDIX

Spatial Regressions - Programs

The field of applied spatial econometrics is still in the development stages with many options available for those wishing to conduct spatial analysis on data. As these tools continue to develop and become more refined the field will benefit and grow. Spatial regression analysis has not yet made it into the mainstream statistical packages as a routine yet there are many options available to run these regressions. Some of the packages follow the Open Source Philosophy "The basic idea behind open source is very simple: When programmers can read, redistribute, and modify the source code for a piece of software, the software evolves. People improve it, people adapt it, and people fix bugs. And this can happen at a speed that, if one is used to the slow pace of conventional software development, seems astonishing"¹³. The following is a brief listing/description of the current software used for spatial econometric analysis.

Geoda and SpaceStat have been created specifically for this type of analysis. Their creator Luc Anselin is one of the foremost authorities on spatial econometrics. Geoda is an open source program that is constantly being updated as it attempts to become a mainstay in the spatial economic analysis. However, the program is still in its infancy and has some bugs that are being worked out through trial and error. A list serve is active for users' questions and update requests.

A nice feature of Geoda is the interface that allows use of ArcView shape files and map projections. The newest updates allow for a series of projected maps over a period of time thus showing a nice visual representation of the change by regions. Additionally you may highlight areas of the map and

¹³ Source: <http://www.opensource.org/>

simultaneously select the data for those areas is selected. Geoda is completely open source and fully functional as a standalone program for spatial analysis.

However, the extents of regressions that are able to run on this program are limited and sometimes must be combined with other packages such as R. For example using a K-nearest neighbor weighting matrix produces results in Geoda but the results are inaccurate as explained by Luc Anselin below¹⁴:

“Although you can run spatial models in GeoDa with k-nearest neighbor matrices, the results are incorrect (the next version of GeoDa will fix this problem). For small N, GeoDa supposedly uses the traditional Ord eigenvalue routine. This will compute eigenvalues but will only use the real part. For asymmetric weights, the roots are complex. The problem is that the complex part is ignored by the routine, so it seems like it works, but, in fact, it is incorrect. So the caveat stands, don't use GeoDa for k-nearest neighbor weights.

The large N regressions in GeoDa use the Smirnov-Anselin characteristic values approach. That only works for symmetric weights and will crash for asymmetric ones (future versions of GeoDa will have a check for this option to avoid crashing). The most appropriate "fix" Luc suggests would be to use R to make the k-nearest neighbor weights symmetric, as Roger suggested”.

Even though this is a very powerful tool caution must be taken when using the results. As with any of the spatial programs discussed here it is very easy to run regressions but you must first understand the processes your statistical package is following before you may use the results. However, the bugs and fixes are monitored very closely on the listserv which gives me great hope for the future of this program.

SpaceStat is the predecessor to Geoda and has been sold to Teraserve software for distribution. SpaceStat runs from dos prompt and leaves a lot to be desired when it comes to user interface. Given the change of ownership and hefty price tag it does not seem to be widely used in the discipline of spatial econometrics. However, Kelly Pace has maintained a variant of his Spatial Statistics Toolbox written in Fortran 90 (SpaceStatPack 1.0). The program is beneficial to those who cannot obtain a copy of the Teraserve program or MATLAB (discussed below). This program by Pace is fully function for spatial estimation and computation. However the user interface is cumbersome for most users when compared to MATLAB or Geoda.

¹⁴ Openspace Digest, Vol 17, Issue 13

MATLAB is a well established software package used for technical computations. It has been used extensively in engineering practices and simulations as well as mathematical computations. It provides core mathematics and advanced graphical tools for data analysis, visualization, and algorithm and application development. With more than 600 mathematical, statistical, and engineering functions, engineers and scientists rely on the MATLAB environment for their technical computing needs. The variability of MATLAB allows it to be programmed to execute almost any mathematical commands. This flexibility has allowed the writing of programs to calculate weighting matrices and compute spatial regressions.

LeSage and Pace have been at the forefront of this effort creating and maintaining several toolbox functions for spatial econometrics. Using their programming skills LeSage and Pace have developed the spatial routines for MATLAB. Their work has also been generously placed on the internet free for anyone to use¹⁵ and contribute too its work. Many updates, bug fixes, and new programs have been developed using this open source format.

Current work on the MATLAB front has been to develop interaction between MATLAB and ESRI products such as ArvMap and other GIS programs. As these routines are in development there are still some bugs yet to be worked out. The high cost of MATLAB creates a barrier for some in their search for spatial programs but there are other options.

SAS and GAUSS have always been at the front of statistical software. Both have the flexibility of writing your own code to execute functions. Given that option many of the MATLAB toolboxes can be converted to function in a SAS or GAUSS environment. However, for anyone familiar with programming the conversion from one language to another can be quite troublesome.

¹⁵ LeSage has a website <http://www.spatial-econometrics.com> and Pace's website is : <http://www.spatial-statistics.com>

STARS¹⁶ is a newly introduced program by Dr. Rey at the University of San Diego. STARS is a data analysis package specifically created for variables measured on geographical units over time. The visual mapping options combined with the statistical analysis creates a very nice interface for spatial time series analysis. Dr. Rey follows the open source format for STARS which makes it readily available for use to anyone. Given the release data of July 2004 I have not had time to work much with this program. However, from what I have seen in the regional meetings it should develop into a very nice spatial analysis package.

¹⁶ <http://stars-py.sf.net>

Sample of VB selection process

```
Sub select_1_8_mile()
```

```
'  
'This function will select cells based on their x and y  
'
```

```
Sheets("Sheet2").Select  
Dim i As Integer  
Dim j As Integer  
Dim k As Integer  
Dim NumOfHouses As Integer  
Dim NumOfCloseHouses As Integer  
Dim TotalPrice As Long  
NumOfHouses = 5632  
Sheets("Sheet2").Cells(1, 8).Value = "Average Price Within 1/8 Mile"  
Sheets("Sheet2").Cells(1, 9).Value = "Number Of Houses Within 1/8 Mile"  
k = 2  
For i = 2 To NumOfHouses  
    NumOfCloseHouses = 0  
    TotalPrice = 0  
    For j = 2 To NumOfHouses  
        'this if statment will retrun true if a house is within 1/8 mile of the current house  
        ' (current cell x) (Iteration cell x) (current cell x) (Iteration cellx)  
        If (Cells(j, 2).Value <= Cells(i, 2).Value + 660) And (Cells(j, 2).Value >= Cells(i, 2).Value - 660) And (Cells(j, 3).Value <=  
Cells(i, 3).Value + 660) And (Cells(j, 3).Value >= Cells(i, 3).Value - 660) Then  
            If (i <> j) Then  
                NumOfCloseHouses = NumOfCloseHouses + 1  
                TotalPrice = TotalPrice + Cells(j, 1).Value  
            End If  
        End If  
    Next j  
    If NumOfCloseHouses > 0 Then  
        Sheets("Sheet2").Cells(k, 8) = TotalPrice / NumOfCloseHouses  
        Sheets("Sheet2").Cells(k, 9) = NumOfCloseHouses  
        k = k + 1  
    Else
```

```

        Sheets("Sheet2").Cells(k, 9) = NumOfCloseHouses
        k = k + 1
    End If
Next i
Dim blah As String
blah = "Done! "
blah = blah + Str$(k - 2)
blah = blah + " houses were found."
Beep
MsgBox blah
End Sub
Sub Select_box_1_4to1_8()
'
'This function will select cells based on their x and y
'
    Sheets("Sheet2").Select
    Dim i As Integer
    Dim j As Integer
    Dim k As Integer
    Dim NumOfHouses As Integer
    Dim NumOfCloseHouses As Integer
    Dim TotalPrice As Long
    NumOfHouses = 5632
    Sheets("Sheet2").Cells(1, 18).Value = "Average Price Within 1/8-1/4 Miles"
    Sheets("Sheet2").Cells(1, 19).Value = "Number Of Houses Within 1/8-1/4c Miles"
    k = 2
    For i = 2 To NumOfHouses
        NumOfCloseHouses = 0
        TotalPrice = 0
        For j = 2 To NumOfHouses
            'this if statment will retrun true if a house is within 1/4 mile but further than 1/8 mile of the current house
            ' (current cell x) (Iteration cell x) (current cell x) (Iteration cellx)
            If ((Cells(j, 2).Value <= Cells(i, 2).Value + 1320) And (Cells(j, 2).Value >= Cells(i, 2).Value + 660) And (Cells(j, 3).Value <=
Cells(i, 3).Value + 1320) And (Cells(j, 3).Value >= Cells(i, 3).Value - 1320)) Or ((Cells(j, 2).Value <= Cells(i, 2).Value - 660) And
(Cells(j, 2).Value >= Cells(i, 2).Value - 1320) And (Cells(j, 3).Value <= Cells(i, 3).Value + 1320) And (Cells(j, 3).Value >= Cells(i,

```

```

3).Value - 1320)) Or ((Cells(j, 2).Value <= Cells(i, 2).Value + 1320) And (Cells(j, 2).Value >= Cells(i, 2).Value - 1320) And (Cells(j,
3).Value <= Cells(i, 3).Value + 1320) And (Cells(j, 3).Value >= Cells(i, 3).Value + 660)) Or ((Cells(j, 2).Value <= Cells(i, 2).Value +
1320) And (Cells(j, 2).Value >= Cells(i, 2).Value - 1320) And (Cells(j, 3).Value <= Cells(i, 3).Value - 1320) And (Cells(j, 3).Value
>= Cells(i, 3).Value - 660)) Then
    If (i <> j) Then
        NumOfCloseHouses = NumOfCloseHouses + 1
        TotalPrice = TotalPrice + Cells(j, 1).Value
    End If
End If
Next j
If NumOfCloseHouses > 0 Then
    Sheets("Sheet2").Cells(k, 18) = TotalPrice / NumOfCloseHouses
    Sheets("Sheet2").Cells(k, 19) = NumOfCloseHouses
    k = k + 1
Else
    Sheets("Sheet2").Cells(k, 19) = NumOfCloseHouses
    k = k + 1
End If
Next i
Dim blah As String
blah = "Done! "
blah = blah + Str$(k - 2)
blah = blah + " houses were found."
Beep
MsgBox blah
End Sub

```

Figure 1-1 Denver Retail Map (Apparel & Household)

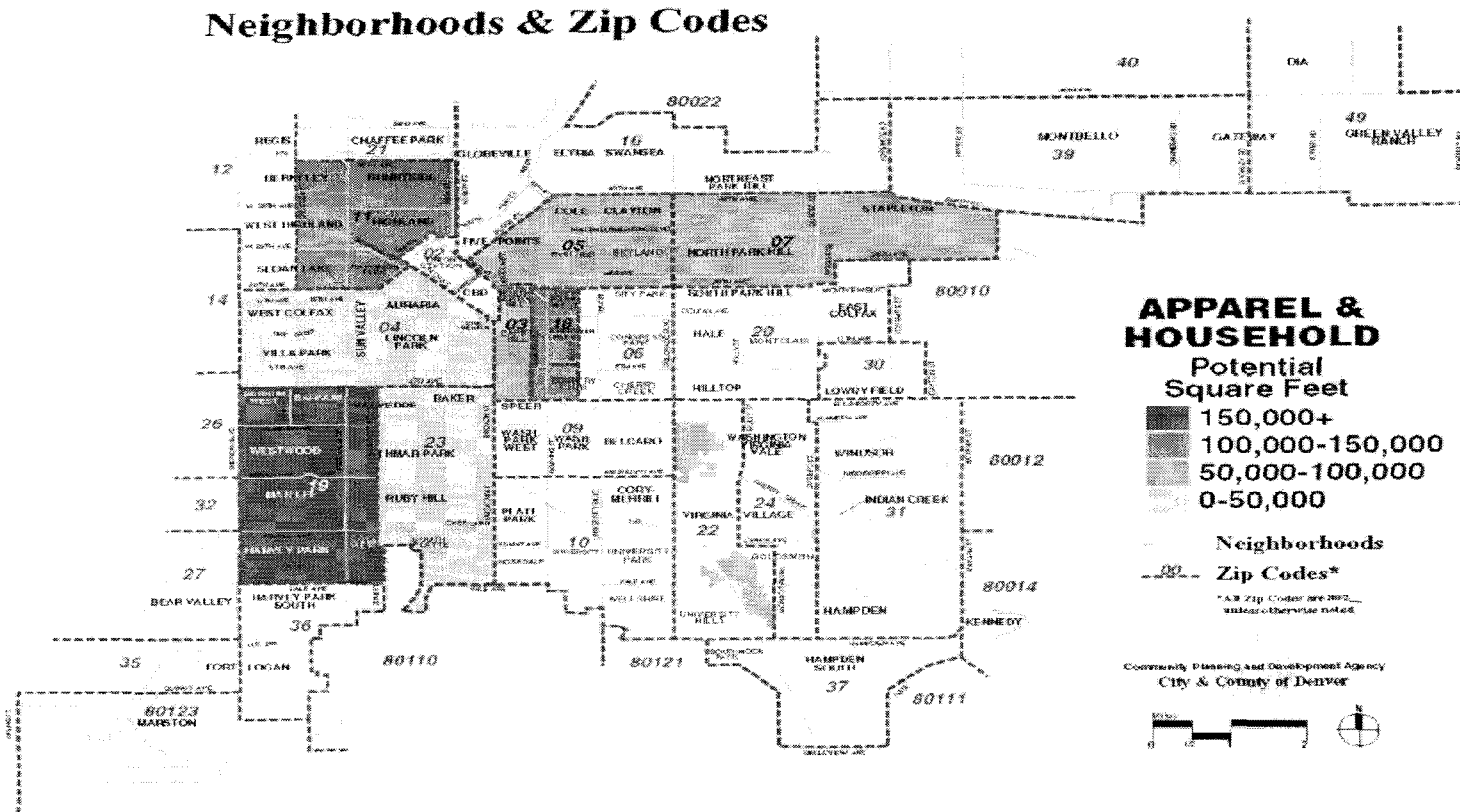


Figure 1-2 Denver Retail Map (Food)

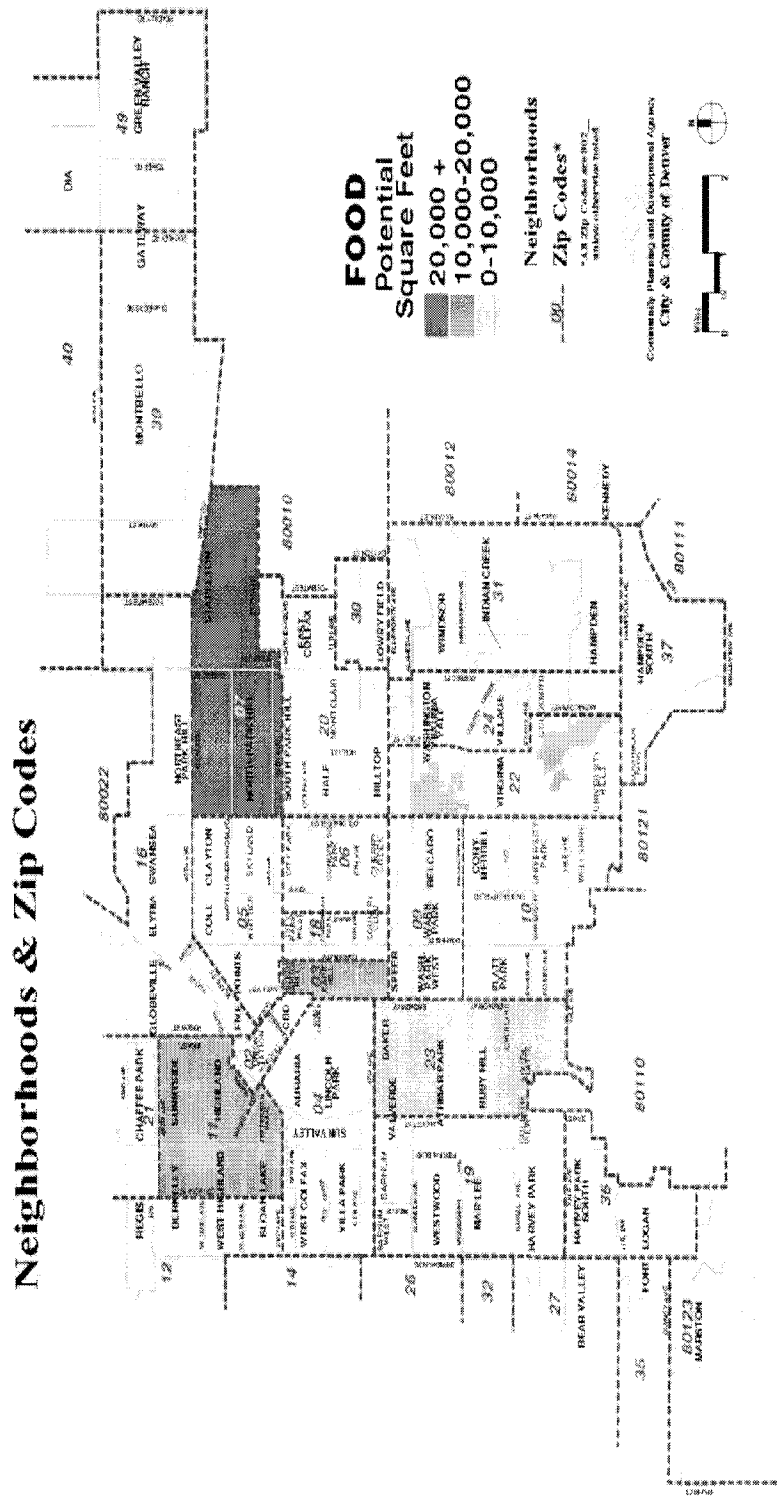


Figure 2-1 Zip Code Statistics 1990

| ZIP | Education (<9 to HS) | Education (HS) | Education (college +) | Unemployment (16-19) | Unemployment (16+) | Median Household Income 1989 | Poverty % (all ages) | Poverty % (18-34) |
|------------|----------------------|----------------|-----------------------|----------------------|--------------------|------------------------------|----------------------|-------------------|
| 80203 | 28.4% | 15.3% | 52.8% | 16.4% | 8.4% | 16,067 | 25.5% | 27.0% |
| 80204 | 40.6% | 15.2% | 16.5% | 27.4% | 11.2% | 15,216 | 36.8% | 34.7% |
| 80205 | 43.6% | 16.2% | 19.9% | 38.2% | 15.7% | 13,327 | 40.6% | 38.6% |
| 80207 | 31.9% | 18.6% | 34.2% | 22.6% | 9.3% | 29,571 | 15.8% | 16.1% |
| 80211 | 41.1% | 15.8% | 19.9% | 31.8% | 9.6% | 19,223 | 26.9% | 26.2% |
| 80216 | 44.7% | 13.0% | 9.9% | 17.0% | 13.2% | 17,210 | 32.9% | 35.1% |
| 80218 | 22.6% | 12.5% | 55.7% | 11.9% | 4.5% | 19,502 | 19.3% | 19.5% |
| 80219 | 43.3% | 21.6% | 19.3% | 32.9% | 9.3% | 23,345 | 19.7% | 21.3% |
| 80223 | 43.8% | 20.9% | 18.3% | 22.7% | 9.9% | 19,289 | 24.9% | 26.1% |
| 8-31Denver | 30.5% | 16.2% | 38.2% | 23.6% | 6.8% | 25,106 | 17.1% | 18.6% |

Figure 2-2 Zip Code Statistics 2000

| ZIP | Education <9 to HS | ED HS | ED college+ | Unemployment 16- 19 | Unemployment16+ | Median HH Income | Poverty % all |
|--------|-----------------------|-------|----------------|------------------------|-----------------|------------------------|------------------|
| 80203 | 23.2 | 16.1 | 42.4 | 18.70% | 5.00% | \$ 27,444 | 20.5% |
| 80204 | 46.5 | 24.1 | 13.8 | 11.80% | 6.10% | \$ 28,247 | 28.5% |
| 80205 | 40.6 | 20.6 | 18.2 | 13.90% | 6.50% | \$ 28,545 | 27.2% |
| 80207 | 36.2 | 22.6 | 31.2 | 10.00% | 3.20% | \$ 41,722 | 14.5% |
| 80211 | 40.7 | 21.9 | 23.4 | 9.60% | 5.50% | \$ 35,753 | 18.8% |
| 80216 | 49.2 | 22.9 | 3.6 | 14.70% | 6.60% | \$ 30,735 | 26.1% |
| 80218 | 19.9 | 14 | 51 | 4.50% | 3.50% | \$ 33,162 | 14.4% |
| 80219 | 51.9 | 28.7 | 8.6 | 7.50% | 3.40% | \$ 36,565 | 15.7% |
| 80223 | 48.8 | 25.8 | 15.1 | 11.90% | 4.90% | \$ 32,853 | 19.5% |
| Denver | 32 | 20 | 34.5 | 12.60% | 3.80% | \$ 39,500 | 14.3% |

Figure 3-2 Denver EPA Hazards and Area of Study

Area of Study

Denver, Colorado

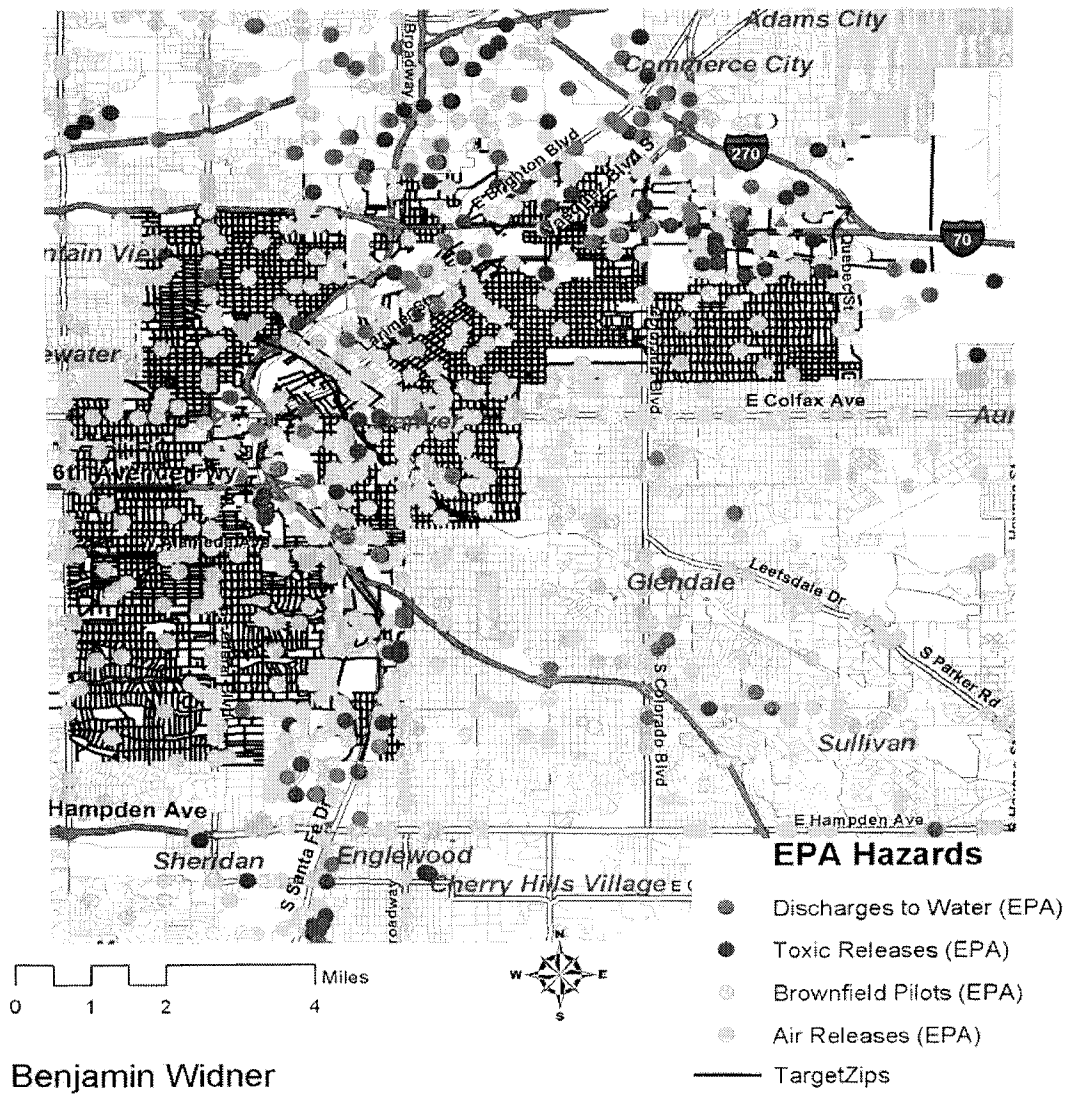


Figure 3-3 Greeley Hazards and Home Sales

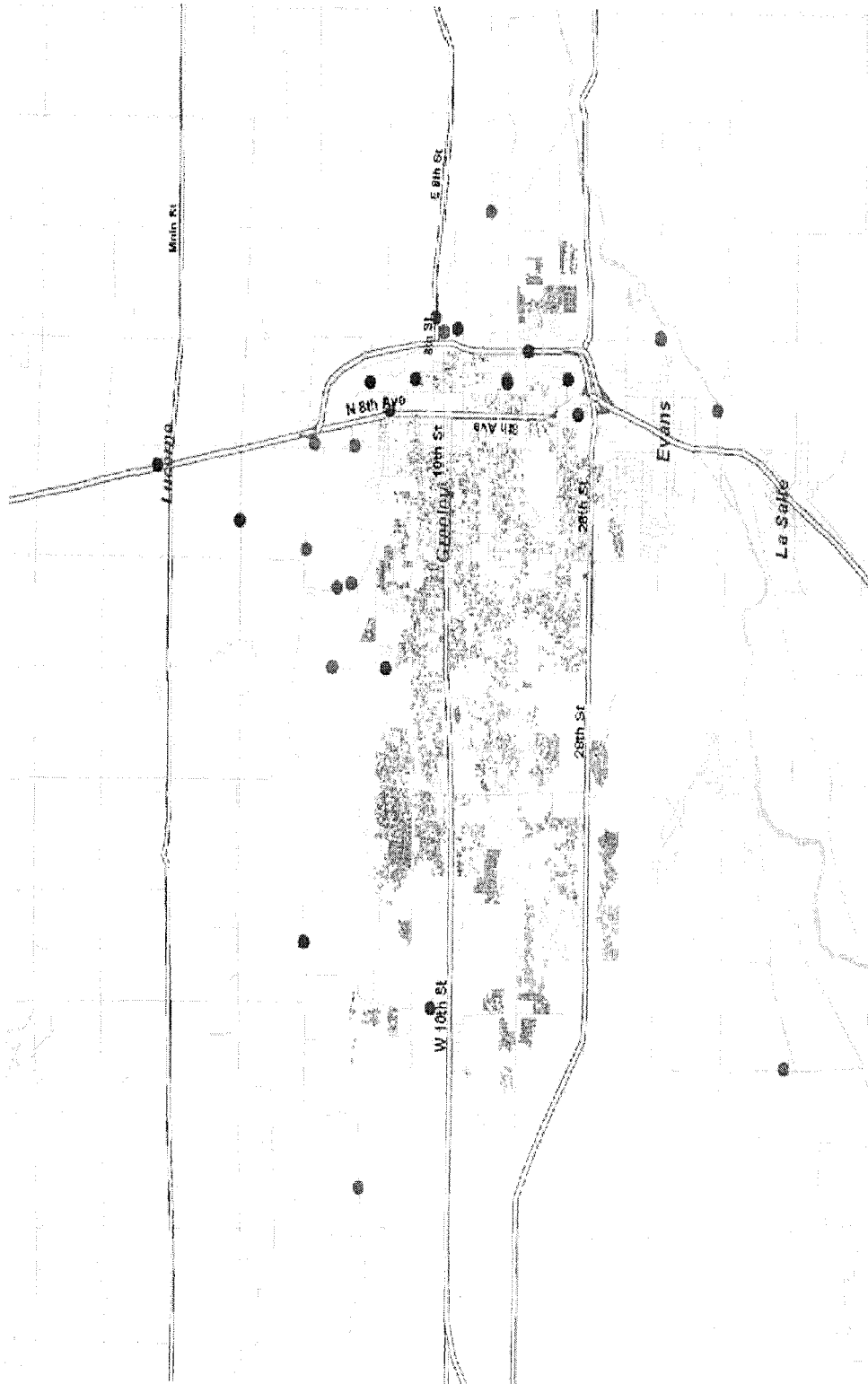


Figure 3-4 Sample T-tests

| | <i>Clean</i> | <i>Gasoline</i> |
|------------------------------|--------------|-----------------|
| Mean | 10.44366197 | 12.36619718 |
| Variance | 6.468209256 | 18.76934105 |
| Observations | 71 | 71 |
| Pearson Correlation | 0.750001868 | |
| Hypothesized Mean Difference | 0 | |
| df | 70 | |
| | - | |
| t Stat | 5.489019527 | |
| P(T<=t) one-tail | 3.04316E-07 | |
| t Critical one-tail | 1.666915068 | |
| P(T<=t) two-tail | 6.08631E-07 | |
| t Critical two-tail | 1.994435479 | |

| | <i>Clean</i> | <i>Dry Cleaning</i> |
|------------------------------|--------------|---------------------|
| Mean | 10.5 | 12.8872549 |
| Variance | 7.28 | 25.05328431 |
| Observations | 51 | 51 |
| Pearson Correlation | 0.693256272 | |
| Hypothesized Mean Difference | 0 | |
| df | 50 | |
| | - | |
| t Stat | 4.621491884 | |
| P(T<=t) one-tail | 1.35382E-05 | |
| t Critical one-tail | 1.675905423 | |
| P(T<=t) two-tail | 2.70764E-05 | |
| t Critical two-tail | 2.008559932 | |

| | <i>Clean</i> | <i>Solvent</i> |
|------------------------------|--------------|----------------|
| Mean | 10.69090909 | 13.25 |
| Variance | 7.550841751 | 24.4375 |
| Observations | 55 | 55 |
| Pearson Correlation | 0.693220067 | |
| Hypothesized Mean Difference | 0 | |
| df | 54 | |
| | - | |
| t Stat | 5.232647673 | |
| P(T<=t) one-tail | 1.39841E-06 | |
| t Critical one-tail | 1.673565748 | |
| P(T<=t) two-tail | 2.79682E-06 | |
| t Critical two-tail | 2.004881026 | |

Figure 3-5 Survey: Contaminated Property Investment Survey

Thank you for participating in this research effort. Your professional experience and judgment are important to us. Please answer the following questions as thoughtfully as possible; be as specific as possible even if you see ambiguities in a question; and please answer from your own personal perspective as a real estate professional.

1. Would you describe yourself as a . . . ? (check all that apply)
 - broker
 - developer
 - financier
 - Investor

2. What types of property do you typically deal in? (choose all that apply)
 - Single-family residential
 - Multi-family residential
 - Retail
 - Office
 - Industrial

3. What size transaction do you typically seek? (choose all that apply)
 - < \$250,000
 - < \$250,000 to \$1million
 - < \$1million to \$5 million
 - > \$5 million

4. Have you ever purchased a property with environmental contamination issues (excluding asbestos & lead based paint)?
 - No
 - Yes, bought it unknowingly
 - Yes, bought it intentionally

5. Which best describes you? (answer one)
 - Will not ever buy contaminated property
 - Try to avoid contamination, but will invest if the economics makes sense.
 - Invest in contaminated (“brownfields”) properties as well as “clean properties.
 - Only invest in contaminated (“brownfields”) properties.

6. Do you intentionally seek contaminated property as an investment?
 - Yes
 - No

7. Have you ever walked away from a potential deal solely because environmental contamination was present?
 - Not always; I will gladly evaluate the potential cost of remediation.
 - No, but I have a limited tolerance for such issues.
 - Yes, based on the appearance or disclosure of environmental issues.
 - Yes, after further investigating the extent of environmental problems.
 - Yes, but only after I determined that remediation cost made the deal infeasible.

8. Have you ever dealt with a property that had a “No Further Action” letter from a state Voluntary Cleanup program?
 - I don’t know what a “voluntary cleanup program” is.
 - No, have never been in that situation
 - No, I don’t deal with contaminated properties.
 - Yes, it lowered my risk and my required rate of return.

9. Yes, but it did not lower my risk or my required rate of return. Have you ever used Environmental Insurance for a property transaction? (Answer all that fit)
 - No, I don’t deal with contaminated properties.
 - No, have never been in a situation that warranted it.
 - No, it’s not worth the cost.
 - Yes, but at someone else’s request, i.e.- a lender
 - Yes, it lowered my risk and my required rate of return.
 - Yes, but it did not lower my risk or my required rate of return.
 - Yes, but it increased my required rate of return.
 - I don’t know what “environmental insurance covers, never dealt with it.

10. When initially evaluating an investment, do you screen for on-site environmental issues (the most fitting answer)
 - As part of initial property inspection.
 - A phase I environmental investigation is always done prior to seeking funding.
 - Only if requested by lender or other financial partner.
 - Only invest in contaminated property

11. If a phase I shows potential problems on-site, do you further investigate and continue to pursue the investment?
 - Yes.
 - No.

12. If Phase I environmental investigation shows potential off-site contamination, do you continue to pursue the investment?
 - Yes.
 - No.

13. If Phase II environmental investigation shows potential on-site contamination, do you typically continue to pursue the investment?
 - Yes.
 - No.

14. Considering again your answer or answers to Question 2, please mark the one type of investment that you most often deal in:

- Multi-family residential
- Retail
- Office
- Industrial

Please consider a fully typical property that you would consider for investment in this category, in terms of property characteristics, price, intended holding period, etc., assuming no contamination problems.

Now, what if an environmental investigation finds a hazardous materials problem contained on-site, with a cleanup cost equal to 15%* of what the initial purchase price would be if the property were clean? Please tell us how this would affect your decision-making, depending on whether the contamination is related to gasoline, dry cleaning, or degreasing solvents. Using a single point value, or a range of values, please indicate your investment criteria under each condition:

* for example 15% equates to a \$37,500 cleanup cost on a \$250,000 investment; \$150,000 on \$1 million investment; \$750,000 on \$5 million investment.

| | If the property is CLEAN | If there is a GASOLINE contamination problem | If there is a DRY CLEANING contamination problem | If there is a DEGREASING/SOLVENT contamination problem |
|---|---|---|---|---|
| Would you still consider investing? | <input type="checkbox"/> Yes <input type="checkbox"/> No | <input type="checkbox"/> Yes <input type="checkbox"/> No | <input type="checkbox"/> Yes <input type="checkbox"/> No | <input type="checkbox"/> Yes <input type="checkbox"/> No |
| Your overall cap rate | ___% | ___% | ___% | ___% |
| Your reversion/terminal cap rate | ___% | ___% | ___% | ___% |
| The discount rate you would apply | ___% | ___% | ___% | ___% |
| Investment holding period? | ___ years | ___ years | ___ years | ___ years |
| Would you also deduct the cleanup costs directly from the resulting purchase price? | N/A | <input type="checkbox"/> Yes <input type="checkbox"/> No | <input type="checkbox"/> Yes <input type="checkbox"/> No | <input type="checkbox"/> Yes <input type="checkbox"/> No |

15. If you marked more than one investment type in Question 2, now please indicate the second most common type that you deal in:

- Multi-family residential
- Retail
- Office
- Industrial

Please consider a fully typical property that you would consider for investment in this second category, in terms of property characteristics, price, intended holding period, etc., assuming no contamination problems.

Now, what if an environmental investigation finds a hazardous materials problem contained on-site, with a cleanup cost equal to 15%* of what the initial purchase price would be if the property were clean? Please tell us how this would affect your decision-making, depending on whether the contamination is related to gasoline, dry cleaning, or degreasing solvents. Using a single point value, or a range of values, please indicate your investment criteria under each condition:

* for example 15% equates to a \$37,500 cleanup cost on a \$250,000 investment; \$150,000 on \$1 million investment; \$750,000 on \$5 million investment.

| | If the property is CLEAN | If there is a GASOLINE contamination problem | If there is a DRY CLEANING contamination problem | If there is a DEGREASING/SOLVENT contamination problem |
|---|---|---|---|---|
| Would you still consider investing? | <input type="checkbox"/> Yes <input type="checkbox"/> No | <input type="checkbox"/> Yes <input type="checkbox"/> No | <input type="checkbox"/> Yes <input type="checkbox"/> No | <input type="checkbox"/> Yes <input type="checkbox"/> No |
| Your overall cap rate | ___% | ___% | ___% | ___% |
| Your reversion/terminal cap rate | ___% | ___% | ___% | ___% |
| The discount rate you would apply | ___% | ___% | ___% | ___% |
| Investment holding period? | ___ years | ___ years | ___ years | ___ years |
| In addition to the above, Would you also deduct the cleanup costs directly from the resulting purchase price? | N/A | <input type="checkbox"/> Yes <input type="checkbox"/> No | <input type="checkbox"/> Yes <input type="checkbox"/> No | <input type="checkbox"/> Yes <input type="checkbox"/> No |

Figure 4-1 additional regressions

Dependent Variable: SALESPLN
 Method: Least Squares
 Date: 05/09/04 Time:
 13:41
 Sample(adjusted): 1 5631
 Included observations: 5595
 Excluded observations: 36 after adjusting endpoints

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|----------|-------------|------------|-------------|--------|
| C | 10.66223 | 0.875691 | 12.17578 | 0 |
| AGE | -0.001641 | 9.11E-05 | 18.00853 | 0 |
| AIR | 0.129155 | 0.007222 | 17.88442 | 0 |
| AT | 1.08E-05 | 5.15E-07 | 20.99729 | 0 |
| BDRM | 0.036987 | 0.004716 | 7.842028 | 0 |
| BTH | 0.161766 | 0.004895 | 33.04696 | 0 |
| FIRE | 0.135879 | 0.007413 | 18.33017 | 0 |
| DTOX1 | 0.024436 | 0.142755 | 0.171172 | 0.8641 |
| DTOX6 | 0.078131 | 0.12189 | 0.640998 | 0.5216 |
| DTOX5 | -0.118978 | 0.182512 | 0.651894 | 0.5145 |
| DTOX4 | -0.007593 | 0.031624 | -0.2401 | 0.8103 |
| DTOX3 | -0.667977 | 0.477714 | 1.398279 | 0.1621 |
| DTOX2 | 0.108084 | 0.107536 | 1.005097 | 0.3149 |
| DTOX8 | 0.765067 | 0.552326 | 1.385174 | 0.1661 |
| DTOX9 | -0.268391 | 0.238804 | 1.123894 | 0.2611 |
| DTOX10 | 0.086548 | 0.102392 | 0.845266 | 0.398 |
| DTOX11 | 0.002464 | 0.019719 | 0.124948 | 0.9006 |
| DTOX12 | -0.003709 | 0.013032 | -0.28459 | 0.776 |
| AP8 | 1.10E-06 | 1.76E-07 | 6.238553 | 0 |
| BOX814 | 6.90E-07 | 2.31E-07 | 2.982728 | 0.0029 |
| BOX1214 | 1.04E-06 | 2.91E-07 | 3.585427 | 0.0003 |