An Economic Analysis of the Value of Local Street Improvements In Springfield, Oregon

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About SCI

The Sustainable Cities Initiative (SCI) is a cross-disciplinary organization at the University of Oregon that promotes education, service, public outreach, and research on the design and development of sustainable cities. We are redefining higher education for the public good and catalyzing community change toward sustainability. Our work addresses sustainability at multiple scales and emerges from the conviction that creating the sustainable city cannot happen within any single discipline. SCI is grounded in cross-disciplinary engagement as the key strategy for improving community sustainability. Our work connects student energy, faculty experience, and community needs to produce innovative, tangible solutions for the creation of a sustainable society.

About SCYP

The Sustainable City Year Program (SCYP) is a year-long partnership between SCI and one city in Oregon, in which students and faculty in courses from across the university collaborate with the partner city on sustainability and livability projects. SCYP faculty and students work in collaboration with staff from the partner city through a variety of studio projects and service-learning courses to provide students with real-world projects to investigate. Students bring energy, enthusiasm, and innovative approaches to difficult, persistent problems. SCYP's primary value derives from collaborations resulting in on-the-ground impact and expanded conversations for a community ready to transition to a more sustainable and livable future. SCY 2011-12 includes courses in Architecture; Arts and Administration; Business; Economics; Journalism; Landscape Architecture; Law; Oregon Leadership in Sustainability; and Planning, Public Policy, and Management.

About Springfield, Oregon

The City of Springfield has been a leader in sustainable practices for more than 30 years, tackling local issues ranging from waste and stormwater management to urban and suburban redevelopment. It is the first and only jurisdiction in Oregon to create two separate Urban Renewal Districts by voter approval. Constrained by dramatic hillsides and rivers to the north and south, Springfield has worked tirelessly to develop efficiently and respectfully within its natural boundary as well as the current urban growth boundary. Springfield is proud of its relationships and ability to work with property owners and developers on difficult developments, reaching agreements that are to the benefit of both the project and the affected property owners. These relationships with citizens are what continue to allow Springfield to turn policy and planning into reality. Springfield recruited a strong, diverse set of partners to supplement city staff participation in SCYP. Partners include the Springfield Utility Board, Willamalane Park and Recreation District, Metro Wastewater Management Commission, United Way of Lane County, and Springfield School District 19.

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Executive Summary

As part of its yearlong partnership with the Sustainable City Year Program, the City of Springfield and United Way of Lane County proposed three projects to the University of Oregon Economics Department's Economic Analysis of Community Issues class. The projects were motivated by the City's interest in key local issues including initial childhood literacy, deteriorating local street conditions, and development of the Glenwood Riverfront District into a vibrant mixed-use environment. Each topic required a different approach, but collectively the projects sought to assess the costs, benefits, and sustainability of programs aimed at addressing these issues, while also proposing additional considerations and areas for improvement.

Students in Economic Analysis of Community Issues completed the projects over the course of two terms. Each student team followed a similar process, beginning with an initial proposal outlining the research question, econometric methodology, and related literature. The teams then gathered local data and analyzed the data using economic and statistical analysis to provide the community partners with greater insight into each issue, as well as valuable statistical data to use in future decision-making. Each project culminated in a final honors thesis and presentation to the community partners.

The first SCY project sought to identify the preliminary impact of United Way of Lane County's low-income Promise Neighborhoods on kindergarten literacy scores. Analysis of Springfield and Bethel School District data suggested Promise Neighborhoods have not had a statistically significant effect on literacy scores to date. However, to effectively track the longer-term effects of Promise Neighborhoods, United Way and local school districts may benefit from adopting a uniform data collection system for student assessments.

The second project attempted to value local street improvements by analyzing the effect of better street conditions on surrounding house values. This analysis indicated better street conditions have a positive effect on house prices for properties with values above a minimum price threshold. However, a cost-benefit analysis based on these findings suggested the private benefits to homeowners from these street improvements do not outweigh project costs, with the exception of paving gravel streets. These findings suggest Springfield can maximize private homeowner benefits by encouraging homeowners on gravel streets to fund paving projects.

The third SCY project examined apartment rent prices surrounding the University of Oregon to determine the feasibility of a student-housing complex in the Glenwood Riverfront District. The project estimated rent prices for three and four bedroom units in a Glenwood student housing development at $1.46 per square foot with a cost per square foot between $115 and $125. Based on these estimates, a 44,000 square foot, 34-unit complex rented at full capacity would recover construction costs in approximately 12.25 years. Due to the relatively long payback period, the City of Springfield may need to incentivize development

through tax abatements or other programs if it believes a student-housing complex can jumpstart investment in the Glenwood region.

Abstract

The City of Springfield faces deteriorating street conditions due to a steady decline in transportation funding. The City believes a possible solution to this problem is to improve its local streets with funding from residential property assessments. However, to encourage property owners to bear the costs of improving roads, the City would like to better understand the value of local street improvements. This paper surveys the existing literature on amenity valuation and infrastructure investment and proposes a hedonic price regression to estimate the impact local street conditions have on residential house prices. Our results suggest better street conditions have a positive effect on Springfield house prices when property values exceed a minimum sales price threshold. Based on these findings, we conduct a cost-benefit analysis of local street improvements and suggest additional considerations for the City of Springfield.

Introduction

With an estimated value of $400 million[1], the Springfield, Oregon street system is one of the City's most valuable infrastructure assets. Its network of over 382 lane miles connects Springfield residents to the City's jobs, schools, businesses, and other resources. It also serves as an important asset for the area's local businesses, facilitating access to the raw materials, inventory, and customers they need to remain competitive. In addition, good roads have been shown to promote economic growth through increases in productivity and reductions in costs of production, both of which help attract new business investment and promote a vibrant local economy[2]. However, like any system of its magnitude, Springfield's network of roads demands continuous maintenance and improvements in order to continue to facilitate the flow of goods and people. Unfortunately, for the past several years, the City's road system has faced serious challenges. Between 2008 and 2010, the percentage of streets professionally evaluated to be in poor condition increased from 23% to over 58% (Springfield Public Works Department, 2010). This decline is largely attributable to a steady decline in transportation funding and the lack of a stable, long-term funding source. These challenges have forced the City's Transportation Engineering Division to begin exploring other ways to improve and maintain its streets.

A specific area of interest for the City is evaluating its more than 228 miles of local streets, many of which have experienced a rapid deterioration in quality in recent years[3]. Local streets are those located within the City's residential

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[1] Estimated value as of 2008.

[2] See Dev Bhatta and Drennan (2003) for a good overview of the literature on transportation investment and economic growth.

[3] See Figure 1 for a breakdown of local streets by pavement quality.

neighborhoods. They typically receive the lowest daily traffic volumes and are currently given the lowest priority for improvement and maintenance. However, the City of Springfield believes there is significant value in its local roads and would like to assess their value to homeowners and the City. Specifically, the City would like to know what effect local street improvements have on surrounding residential property values in order to determine whether it should alter its policies to encourage more local street improvement projects.

To date, numerous studies have sought to value similar locational and environmental amenities that lack directly observable prices. They have accomplished this by analyzing the impact the amenities have on house values. This approach has been used in studies by Gonzalez-Navarro and Quintana-Domeque (2010) to assess the value of paving in Acayucan, Mexico and by Donovan and Butry (2009) to value street trees in Portland, Oregon, among others. However, the value of local street improvements remains largely unexamined to this point, particularly in an environment like Springfield, Oregon. Thus, the goal of this paper is to estimate the impact to Springfield homeowners of having better streets and to use our findings to conduct a cost-benefit analysis of local street improvements. We then use these results to examine potential explanations for the lack of local street improvements.

To evaluate the value of local street improvements we use a hedonic price regression. The hedonic price regression allows us to isolate the effects of individual street improvement variables and estimate the value of improving local streets to various conditions. We use data on house sales prices and other house characteristics from the Regional Land Information Database (RLID) that is maintained by Lane County, the cities of Eugene and Springfield, the Eugene Water and Electric Board, and the Lane Council of Governments. We also use local street classification and street condition data from the City of Springfield.

Based on Springfield data, our empirical analysis suggests local street improvements increase property values for homes with sale prices above a minimum threshold. We find that for a one-point increase in the City's street pavement condition rating[4], house values increase between 0.06% and 0.07%, on average. We also estimate that asphalt streets command a 16% higher sale price than gravel streets, on average. Based on these estimates, our cost-benefit analysis indicates that total costs substantially exceed the private benefits from improving existing street pavement. However, private benefits tend to outweigh total costs for paving gravel streets. These results indicate the City's current policy failure may be due to a combination of costs exceeding private benefits, as well as a lack of homeowner knowledge about the property value benefits of asphalt pavement.

The rest of the paper is structured as follows. In Sections 2 and 3, we outline Springfield's current street policies and offer potential economic explanations for

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[4] The City of Springfield grades its street using a Street Condition Index (SCI) rating ranging from 0 to 99.99. The SCI rating is described in more detail in the following section.

the lack of local street improvements. Section 4 surveys the existing literature. Sections 5 and 6 describe the empirical methodology and data we use for this analysis. Section 7 presents our regression results and cost-benefit analysis. And Section 8 presents our conclusions.

City Policies

The City of Springfield sorts its streets into one of three functional classifications: (1) minor arterials, (2) collectors, and (3) local streets[5]. Minor arterial streets and collector streets receive higher traffic volumes than local streets and, as a consequence, higher priority for maintenance and improvements. However, for purposes of this analysis, we are specifically interested in the third classification: local streets. Local streets are primarily two-lane, paved roadways located in residential neighborhoods. They have little to no striping and handle the lowest daily traffic volumes – usually no more than 1,500 vehicles per day (Springfield Public Works Department, 2010).

The City further decomposes local streets into three categories based on their degree of construction: (1) improved streets, (2) partially improved streets, and (3) unimproved streets. Improved streets are engineered streets that have been improved to location-specific, full urban standards. This usually includes paving, curbs, gutters, drainage, sidewalks, street trees, street lights, and traffic control devices. Partially improved streets are also engineered streets, but typically lack one or more of the full urban standard amenities – sidewalks, street lights, etc. – that are appropriate for the particular location. Unimproved streets are streets with a gravel or asphalt mat surface and little or no structural engineering. Every two years, the City also conducts a pavement assessment that further classifies the streets into good, fair, or poor condition. The assessment is made through the Hansen Pavement Management System, which uses a Street Condition Index rating to grade the road conditions. The index is calculated by assessing the type of surface defect[6], the severity of the defect, and the amount of surface area it covers. The Hansen Pavement Management System has been used by the City of Springfield since 2006 (Springfield Public Works Department, 2010).

At present, the primary funding sources for street maintenance and improvements are a $0.03 Local Fuel Tax and Highway Trust Fund revenues that come from state fuel taxes and license and registration fees (Springfield Public Works Department, 2010). But in recent years, revenues from these sources have not been sufficient to cover maintenance costs, let alone any improvements or long-term preservation efforts. Thus, all preservation work conducted in recent years has been funded by federal stimulus funds or one-time System Development Charges (SDCs).

One important difference between local streets and other street classifications is that City policy currently requires property owners to propose and cover the costs

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[5] A breakdown of the street system by functional classification is provided in Figure 2.
[6] Surface defects include raveling, cracking, and base failure. See Figure 3 for examples of these defects.

of any local street improvements or significant local street maintenance. This policy means any improvement or maintenance projects for local streets require homeowners in the neighborhood to form a Local Improvement District (LID). In doing so, the property owners agree to a property assessment to fund the project. The assessment is typically based on the amount of each homeowner's property that abuts the street. Ultimately, the result of this policy has been very few improvements to Springfield's local streets and a deteriorating local street network. However, the City hopes to encourage more local road improvements if it can show homeowners that the property value benefits are substantial enough to offset the costs.

Economic Theory

The motivation for this study is the ineffectiveness of the City of Springfield's current road improvement policy at encouraging local street improvements. However, the source of this policy failure is currently unclear, leading us to consider some of the fundamental economic reasons this policy breakdown exists. Ultimately, this analysis of possible economic explanations for the current policy failure is crucial for fully understanding the problem and recommending appropriate policy changes. We outline five possible reasons below. Through our analysis, we specifically address the first two possibilities.

The benefits to the homeowners and the City do not outweigh the costs.

Although from a broader view, studies show that road infrastructure development impacts the local economy positively (Queiroz & Gautam, 1992; Gramlich, 1994; Perkins et al., 2005), there is still a possibility that the collective private and public benefits for homeowners and the City, are smaller than the cost of the street improvements. This result could be caused by a variety of factors including fluctuations in real estate values, high materials and labor costs, or reduced safety for cyclists and pedestrians. In this case, homeowners will not favor improving local streets and the City should either abandon the project or find ways to lower the cost of the improvements.

Homeowners are not fully informed about how the private benefits outweigh the costs.

A second possibility is that a street improvement would make homeowners better off, but they are unaware that the private benefits outweigh the costs. This information failure could have various causes. One potential reason could be a lack of previous research to quantify the impact of street conditions on house prices. In this case, data proving the positive benefit to homeowners would not be factored into the homeowners' decision-making process. This is the City of Springfield's current view of the problem. If this were the case, the City's best option would be to provide tangible evidence of the potential increase in house values, as well as detailed information about the financing process through which homeowners would pay for the project. Ultimately, the City's goal in this situation should be to provide homeowners with complete information about the costs and benefits of street improvements. In theory, if homeowners are convinced they will be better off by improving their streets, this should lead to more local street improvements.

The benefits do not outweigh costs for homeowners, but the benefits do outweigh the costs collectively for the City and homeowners.

As previously mentioned, studies show that investment in road infrastructure correlates positively with a successful local economy. This view suggests the City is among the groups likely to benefit from street improvements. Therefore, it could be the case that the cost of improving the street for homeowners exceeds the direct benefits they would gain from this investment, but that the additional public benefit the City receives due to factors like other drivers using these roads, more desirable living conditions attracting new residents, lower maintenance costs, etc. are large enough to make the City, as a whole, better off. In this scenario, although the City might try to encourage residents to improve their streets, property owners will lack the incentive to comply if they are forced to cover the entire cost. The City would, therefore, need to reevaluate whether homeowners ought to be responsible for the entire improvement cost or whether it would be beneficial to all stakeholders if the City also covered a portion of the cost by increasing taxes.

The private benefits outweigh the costs for the homeowners, but there is a coordination failure.

This scenario suggests residents know they might gain from a street improvement, but hesitate to make a commitment without knowing other homeowners' decisions. As Weber et al. (2001) found, with a relatively large group of people involved in a decision-making process, the group rarely chooses the option that is optimal for everyone. A study by Gale (1995) also proved that when there are a sufficiently large number of players involved in a game, the "well-behaved" equilibrium can be delayed infinitely. So, although it may be optimal to proceed with the street improvement, coordination failure may prevent the neighborhood from reaching this optimal outcome. Coordination failure might occur in this process because homeowners worry they will get stuck with a large portion of the cost if their neighbors do not also plan to commit to the project or because one homeowner refuses to cooperate with the rest of the neighborhood, raising doubts about the project's success. Thus, even if everyone knows the street improvement is in their best interest, they still may not undertake the project due to the risk and uncertainty. In this case, the City's priority would be to facilitate cooperation and sharing of information between property owners. As was demonstrated by Dimitri (2003), even if information exchanged is "noisy" in these situations, the parties can still succeed in coordinating their actions if the method of obtaining the information is reliable.

The private benefits outweigh the costs for the homeowners, but they do not have the liquidity to fund the project.

There may also be the case that homeowners know the potential benefits of this investment, but lack the liquidity to finance the project. In this case, even if many homeowners are interested in improving their streets, it may not be realistic for them to invest a significant portion of their cash holdings in an illiquid asset like their house. Additionally, if homeowners do not have the desire or ability to sell their homes, they will not be able to cash out of this investment. Under this scenario, the City could consider ways to spread the cost over a longer time period to make the payments manageable for homeowners or attempt to reduce the overall cost of the project.

Literature Review

City Policies

Many studies analyzing road infrastructure investment have been done in the past. In general, the relevant literature can be viewed from two aspects. First, more conceptual studies about the general impact of road infrastructure on the local and regional economy, which tie to the cities' policies. And second, literature about the actual effects of infrastructure changes on the local economy.

Much of the existing research indicates a positive impact from road infrastructure on the economic development of an area (Queiroz & Gautam, 1992; Gramlich, 1994; Perkins et al., 2005). For example, Queiroz and Gautam (1992) suggest that the per capita stock of road infrastructure is significantly larger in economies with higher incomes than in middle- and low-income economies. In addition, a study in Europe and central Asia showed that a better quality road network could produce better profits for a region than a comparable program like a tariff reduction (Shepherd & Wilson, 2008). These studies suggest there are significant potential gains to be realized from investment in transportation systems. However, discussion of the role of local roads has largely been overlooked to this point, so it remains to be seen what benefits these roads might contribute.

There is also evidence in the literature suggesting a larger U.S. road infrastructure problem. Peterson (2009) notes that U.S. road infrastructure earned a D-minus based on the American Society of Civil Engineers' scale, suggesting the serious need for improvements around the country. However, the problem has been growing due to problems such as tight government budgets and unclear short-term expected returns (Greenstone & Looney, 2011). Also, as noted in Walle (2002), some important but unknown benefits to society from road construction – e.g. poverty reduction – cannot be measured in monetary terms, which may also be causing a reduction in road infrastructure spending. Ultimately, the reduction of road maintenance and improvement may balance government budgets today, but leave a heavy burden for future generations. Some studies have even suggested that the postponement of street maintenance and improvement could actually leave the government with larger expenses in the future as some streets may require complete reconstruction, rather than maintenance and repairs (Greenstone & Looney, 2011; Donnges et. al, 2007). These findings are particularly relevant for our analysis because they suggest there may be benefits to the City of Springfield from local street improvements, in addition to any private benefits and additional tax revenue they generate. Also, cross-sectional analysis was used in some of the relevant studies and many recommend cost-benefit analysis be used when making or evaluating city policies[7]. However, because most of the existing literature focuses on entire street networks, the impact of local streets is still relatively unknown.

Hedonic Pricing and Amenity Valuation

While the benefits of transportation infrastructure investment to local and regional economies – particularly investment in highways, arterial roads, and other high-volume streets – have been well documented, the benefits specific to local, residential streets have largely been overlooked. However, one approach to valuing the benefits of these local roads has been to treat them as a type of neighborhood amenity that impacts the surrounding house values (Gonzalez-Navarro & Quintana-Domeque, 2010). The impact of amenities on house prices has been extensively discussed in the literature and offers a valuable guide for our research question and methodology.

The impact of locational and structural amenities on house values has received extensive attention in the literature since Rosen (1974) first established the basic theory and applications of hedonic models[8]. Rosen defined hedonic prices as implicit prices of attributes, which are revealed to economic agents from observed prices of differentiated products and the specific amounts of the associated characteristics. Based on Rosen's work, many studies have applied hedonic theory to the valuation of locational and environmental amenities, using house prices to determine their implicit market values. The value of hedonic models in assessing these types of amenities is that they largely solve the problem of heterogeneity in housing (Sirmans et al., 2005). Since houses are made up of different attributes that can take different values when packaged in different combinations, a method for isolating these individual characteristics is needed. Hedonic price regressions allow the price of houses to be broken down into a set of individual characteristics and thus serve as a valuable tool for these analyses.

In Sirmans et al. (2005), the authors conducted an extensive review of 125 studies that used hedonic price modeling to value amenities. Their work revealed that residential street conditions have largely been overlooked by previous studies. However, some work has sought to value related amenities. Studies by Anderson and Cordell (1988) and Donovan and Butry (2009) examined the impact of trees on house sales prices in Athens, Georgia and Portland, Oregon, respectively. Both studies concluded that increasing the number of trees adds positively to house values and that the effects are greater for mature trees that provide a larger canopy. The studies estimated the average effect of adding trees at between 3% and 4.5% of the sales price. These findings may have important implications for our research question because street trees are typically a

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[7] See Greenstone & Looney (2011), Shepherd & Wilson (2008), Walle (2002), Hamlett & Baumel (1990), Queiroz & Gautam (1992).

[8] See Picard et al. (2010) for further discussion of the findings and limitations of Rosen's initial work on hedonic pricing and subsequent revisions to the theory.

component of improved local streets. Thus, homeowners may receive additional benefits from street improvements beyond the upgraded pavement quality. These studies also suggest the full-benefits of street trees might not be realized until the trees mature, and thus some benefits of local street improvements might not be experienced by homeowners who sell their houses before a certain point. However, despite the strong findings of these studies, the effects of trees are highly location-specific and make broad application of these findings problematic. Also, further work is needed to determine how street tree effects interact with other components of street improvements, like street lights and traffic controls.

The most relevant literature to-date regarding the value of local roads is a 2010 study by Gonzalez-Navarro and Quintana-Domeque (2010). Gonzalez-Navarro and Quintana-Domeque worked with the local government in Acayucan, Mexico between 2006 and 2009 to randomly pave 28 of the City's residential streets[9]. They formed control and treatment groups each consisting of 28 streets in order to avoid the selection bias typical in studies of this type. By March 2009, 17 of the pavement projects were complete. The study found that house values along these 17 paved roads increased by 23%-27% according to homeowners and by 16-17% according to a professional appraisal, after correcting for downward bias. The study also concluded that the sum of the total benefits was 141% of total construction costs. While this study found a significant impact from local street paving, a few notable deficiencies in the study are apparent. Most notably, the study used appraised values and home values reported by homeowners to measure the effects of the paving. The problem with this measurement method is that the estimates may not reflect the true market value of the houses before and after the paving projects. In addition, this study only looked at the effect of installing basic concrete pavement without the additional amenities of a fully improved local street. Furthermore, differences between the survey area of this study and the survey area of our study are substantial. The most obvious differences are in the initial conditions of the residential streets and the overall level of transportation infrastructure development in the two regions.

After surveying the literature, it is clear a statistical analysis of local streets and local street improvements would help fill a void in the existing literature. To date, existing literature on the benefits of transportation investment focuses almost exclusively on the economic benefits of highways and high-traffic city streets. However, relatively little is known regarding the benefits of a city's local streets, which are likely to provide much different benefits than those from highways and arterials. Additionally, a handful of studies have used hedonic price regressions to estimate the value of individual components of local streets, but no study has evaluated the combination of amenities provided by local street improvements. Thus, using local data we attempt to provide the City of Springfield with more relevant estimates of the impact of local street improvements and add a new perspective to the existing transportation investment literature.

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[9] These streets were previously unpaved, dirt roads.

Hypothesis and Methodology

Our paper seeks to answer two main questions. First, does the condition of Springfield's local streets affect the value of residential house prices? The null hypothesis for this test is street improvements have no effect on house prices and the alternative hypothesis is street improvements have a positive effect on house prices. The second question we attempt to answer is whether potential private benefits from local street improvements are large enough to cover the total costs of improvement. We initially hypothesize that local street improvements have a positive effect on house prices, but we do not expect these private benefits to be large enough to cover the overall construction costs.

To test our first hypothesis, we use a hedonic price regression and run our regression using Ordinary Least Squares (OLS). As Cheshire and Sheppard[10] note, houses are composite goods. That is, the price of a house is equal to the value of its individual structural and locational characteristics. Thus, a hedonic price regression allows us to break house prices into these individual characteristics and estimate their effects. Hedonic theory does not specify the use of a particular functional form, so we use a semi-logarithmic specification thanks to its ease of interpretation and other useful properties[11]. Therefore, our base model is:

$$\text{lprice}_i = \beta_0 + \beta_1\text{lacres}_i + \beta_2\text{no\_bedrooms}_i + \beta_3\text{no\_fullbaths}_i + \beta_4\text{no\_halfbaths}_i + \beta_5\text{year\_built}_i + \beta_6\text{total\_finish\_sqft}_i + \beta_7\text{attached\_garsf}_i + \beta_8\text{attached\_carportsf}_i + \beta_9\text{roof\_cedar\_wood}_i + \beta_{10}\text{fireplace}_i + \beta_{11}\text{y2}_i + \beta_{12}\text{y3}_i + \beta_{13}\text{y4}_i + \beta_{14}\text{y5}_i + \beta_{15}\text{y6}_i + \beta_{16}\text{y7}_i + \varepsilon_i$$

where ε_I represents the error term. To this base model, we add a continuous variable for SCI pavement rating and indicator variables for street classification and pavement type. A description of variables is provided in Table 1.

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[10] Unpublished, date unknown.

[11] Sirmans et al. (2005) note that many studies have attempted to specify a correct functional form for hedonic price regressions, but no consensus has been reached. However, Malpezzi (2003) suggests features of the semi-log model make it preferable to linear models.

Table 1: Description of Variables

Variable	*Definition*
lprice	Natural log of sale price (in US $)
lacres	Natural log of total acres
no_bedrooms	Total number of bedrooms
no_fullbaths	Total number of full bathrooms
no_halfbaths	Total number of half bathrooms
year_built	Year house was built
total_finish_sqft	Total finished square footage of residence
attached_garsf	Total attached garage square footage
attached_carportsf	Total attached carport square footage
roof_cedar_wood	Dummy variable indicating whether house has cedar wood roof (=1 if yes, =0 if otherwise)
fireplace	Dummy variable indicating whether house has fireplace (=1 if yes, =0 otherwise)
y2-y7	Year dummy variables representing each year from 2006 to 2012 (=1 if sale occurred in that year, =0 otherwise)
SCI	SCI pavement condition rating (from 0.00 to 99.99, with higher values representing better pavement conditions)
gravel	Dummy variable indicating street with a gravel surface (=1 if yes, =0 otherwise)
asphalt	Dummy variable indicating street with an asphalt surface (=1 if yes, =0 otherwise)
unimproved	Dummy variable indicating street is classified as unimproved (=1 if sale, =0 otherwise)
part_improved	Dummy variable indicating street is classified as partially improved (=1 if sale, =0 otherwise)
improved	Dummy variable indicating street is classified as fully improved (=1 if yes, =0 otherwise)

Our variables of interest are the SCI pavement condition variable and dummy variables indicating pavement type and functional classification. The coefficients on these variables allow us to estimate their effects on house prices. Specifically, we look at the effect of moving from one pavement condition and classification to another.

As previously mentioned, we use the natural log of the house sale price as our dependent variable to present the estimated effects in percentage terms rather than dollar terms. This makes the results of our analysis more widely applicable to a range of home values[12]. The inclusion of dummy variables for each year between 2006 and 2012[13] allows us to control for any exogenous annual

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[12] Sirmans and Macpherson (2003) discuss this benefit of the semi-log form.

[13] The earliest available house sales data is from 1992. However, it is problematic to assume the street conditions today are the same as they were many years in the past. Thus, our study will focus on a six-year period between 2006 and 2012, as current pavement conditions should still be reasonably similar to those in 2006.

changes in the real estate market that effect all houses, such as the recent U.S. real estate bubble and subsequent collapse of the real estate market. Our other control variables were chosen based on availability in the RLID database and a review of previous studies including Sirmans and Macpherson (2003), Ogwang and Wang (2003), and Cebula (2009). Although additional house characteristics, such as type of heating system, were available in our data set, we do not include these characteristics in our model because specification tests[14] suggest they do not add much explanatory power.

After obtaining estimates of the impact of street improvements on house prices, we conduct a cost-benefit analysis to determine whether any private benefits to homeowners resulting from improvements are great enough to outweigh the total costs, or whether there exists a gap that should be funded by the City if enough additional public benefit exists. We use the estimates obtained from our regression to calculate an estimate of the total benefit to homeowners of living on a street with better pavement condition, an asphalt surface, and an "improved" classification. We then compare this benefit to the total cost of the street improvement using the City's estimated price to improve of $450 per linear foot, and an estimate of the average street length[15] attributable to each property owner.

Data

Our primary data for this analysis comes from the Regional Land Information Database of Lane County (RLID). RLID is the byproduct of over 35 years of collaboration between Lane County, the cities of Eugene and Springfield, the Eugene Water and Electric Board, and the Lane Council of Governments. It is the most extensive source of local land data with property information and characteristics for each tax lot in Lane County. The database features both commercial and residential properties with data including city affiliation, zoning classification, lot size, square footage, year built, number of bedrooms, number of half and full bathrooms, roof type, assessed value, and past sales prices and transaction dates[16]. The RLID data allows us to control for key property characteristics and isolate the effects of our street variables. However, the focus of our study is the area within the City of Springfield so we first drop all properties that fall outside Springfield's city limits. We also exclude all properties that do not have a single-family residence land-use code and remove any duplicate records. We restrict this analysis to single-family homes because duplexes and apartments are more likely to be occupied on a temporary basis by renters, rather than the actual property owners, and thus have values influenced by a different set of factors. Our analysis is conducted at the individual property level and covers the period between 2006 and 2012. We conduct this analysis at the

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[14] We used the Lagrange Multiplier Test for adding a variable to determine which additional control variables to include and omit from our model.

[15] Measured in linear feet.

[16] Data on past sales transactions date back to January 1, 1992.

individual property level because the nature of the City's street improvement policy requires decisions to be made by individual homeowners.

Springfield street data was obtained from the City of Springfield's Transportation Engineering Division. This data includes information on the functional classification of each street segment, the assessed pavement condition of each street segment, and the pavement type for each street segment. The pavement condition rating reflects the condition as of the last street assessment in 2010. The average segment length in our study is approximately 382 linear feet, or typically about one block.

To match Springfield street data to the housing data from RLID, we determined which addresses fell along each street segment using Google Maps and the RLID database's property maps, and then added the street data for each segment to the corresponding properties[17]. We then used the unique maplot numbers associated with each property to merge the street condition data with the corresponding property characteristics from RLID. Summary statistics for the data are provided in Table 2.

Table 2: Descriptive Statistics

VARIABLE	mean	sd	min	max
sale_price	178432.67	80832.10	40000.0	580000
total_acres	0.25	0.16	0.1	1
no_bedrooms	2.87	0.59	1.0	5
no_fullbaths	1.50	0.59	1.0	4
no_halfbaths	0.17	0.39	0.0	2
total_finish_sqft	1324.14	486.46	559.0	4075
year_built	1971.48	22.33	1910.0	2010
attached_garsf	321.53	228.52	0.0	1046
attached_carportsf	6.37	45.08	0.0	414
roof_cedar_wood	0.08	0.27	0.0	1
fireplace	0.36	0.48	0.0	1
y2	0.21	0.41	0.0	1
y3	0.12	0.32	0.0	1
y4	0.17	0.38	0.0	1
y5	0.11	0.32	0.0	1
y6	0.09	0.29	0.0	1
y7	0.02	0.13	0.0	1
improved	0.76	0.43	0.0	1
part_improved	0.04	0.20	0.0	1
unimproved	0.20	0.40	0.0	1
asphalt	0.93	0.25	0.0	1
gravel	0.07	0.25	0.0	1
sci	36.90	23.39	0.0	85
N	440			

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[17] See Figure 4 for an outline of the sample area.

Ideally for this analysis we would have preferred completely randomized data. The most effective way to ensure this randomization would have been for the City of Springfield to randomly select groups of streets to improve to various classification standards and also to randomly select a control group of streets to leave in their current state. This would have allowed us to conduct a paving experiment similar to the one successfully executed by Gonzalez-Navarro and Quintana-Domeque (2010). However, due to time constraints and the City of Springfield's budget limitations we were not able to obtain this ideal, randomized data. We also hoped to make use of any naturally occurring randomization that might exist. For example, if the City put in a number of roads at approximately the same time and some deteriorated more than others due to an idiosyncratic factor like the underlying terrain, this might have also provided the randomization we needed to obtain unbiased estimates of the impact of street condition on house prices. Unfortunately, there is no evidence of this type of naturally occurring phenomenon. Without randomization there is the potential for unobserved factors, or confounding variables, to systematically bias our estimates[18]. For example, if the City only improves streets at the request of property owners, the impact of these street improvements might be overstated due to additional homeowner or neighborhood characteristics that we are unable to control.

Another potential issue with the available data is a lack of past local street improvements. Springfield homeowners have improved very few streets through the LID process and the City has also given local streets low priority for improvements. Assessing the impact of street improvements is difficult without any past improvements to analyze. Thus, we perform a cross-sectional analysis in which we compare neighborhoods that appear similar in all respects except for the condition of their roads, and then compare the house values in the neighborhoods. But while this process allows us to provide the City with estimates of local street improvement benefits, these estimates have statistical flaws and may not accurately reflect the true effects. The issue here is again a confounding variable problem. In this case, unobserved variables may be partly responsible for the variation in house prices. However, our model may wrongly attribute the effects of these variables to the difference in street quality, likely resulting in an upward bias of our estimates.

Results

To test our hypothesis, we first run a series of regressions using our base model and our variables for street condition, functional classification, and surface type. The regressions are outlined in Sections 7.1-7.4. For each regression, we test for heteroskedasticity using White's test and correct for heteroskedasticity using White's (1980) procedure to obtain robust standard errors[19]. All coefficient estimates are interpreted ceteris paribus. We conclude by performing a cost-

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[18] See Schulz and Grimes (2008) for a brief discussion of the benefits of randomization.

[19] We also considered bootstrapped standard errors to correct for heteroskedasticity, but follow Cebula (2009) and report standard errors corrected using White's procedure.

benefit analysis based on our coefficient estimates. Due to the potential for our estimates to demonstrate an upward bias, these results should be viewed as optimistic estimates of street condition effects.

Base Hedonic Regression: Excluding Street Variables

We first regress our base model, excluding our street variables of interest, to determine the overall fit of the model and provide a basis for comparing our street condition models. Our base model is as follows:

$$(1) \quad lprice_i = \beta_0 + \beta_1 lacres_i + \beta_2 no\_bedrooms_i + \beta_3 no\_fullbaths_i + \beta_4 no\_halfbaths_i + \beta_5 year\_built_i + \beta_6 total\_finish\_sqft_i + \beta_7 attached\_garsf_i + \beta_8 attached\_carportsf_i + \beta_9 roof\_cedar\_wood_i + \beta_{10} fireplace_i + \beta_{11} y2_i + \beta_{12} y3_i + \beta_{13} y4_i + \beta_{14} y5_i + \beta_{15} y6_i + \beta_{16} y7_i + \varepsilon_i$$

The results of this regression, shown in Table 3, suggest our control variables explain about 42% of the variability in sale price. This R^2 is somewhat low, but generally within the range found in previous studies[20]. The F-Value is also significant well beyond the 1% significance level, indicating the joint significance of the control variables and the overall strength of our model.

Table 3: OLS Estimates - Base Model for Dependent Variable Natural Log of Sale Price

EXPLANTORY VARIABLES	
lacres	-0.152***
	(0.0513)
no_bedrooms	-0.110***
	(0.0377)
no_fullbaths	-0.0113
	(0.0589)
no_halfbaths	-0.130*
	(0.0692)
total_finish_sqft	0.000513***
	(7.47e-05)
year_built	0.000140
	(0.00153)
attached_garsf	0.000553***
	(0.000118)
attached_carportsf	-0.000412
	(0.000371)
roof_cedar_wood	0.130***
	(0.0422)
fireplace	0.0797***

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[20] See Cebula (2009), Donovan & Butry (2009), Ogwang & Wang (2003).

	(0.0283)
y2	0.0748**
	(0.0353)
y3	-0.000468
	(0.0369)
y4	-0.279***
	(0.0637)
y5	-0.137**
	(0.0590)
y6	-0.369***
	(0.0593)
y7	-0.472***
	(0.0834)
Constant	11.04***
	(2.975)
Observations	439
R-squared	0.423
F	28.29

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The negative coefficient estimates on the bedroom and bathroom variables are less common in these types of studies[21], but can be explained by the inclusion of the square footage variable. Because we control for square footage, adding additional bedrooms and bathrooms generally results in a smaller and less desirable living space. Our $lacres_i$ variable also takes a negative coefficient estimate, which is unusual based on Sirmans and Macpherson's (2003) findings. To attempt to explain this result, we first winsorized the $total\_acres_i$ variable to control for outliers, which had a very minimal effect on our estimates. However, by restricting the sample to properties whose sale prices are above the sample mean of $178,384, the coefficient on the $lacres_i$ variable becomes positive. This seems to indicate that larger lot sizes are less desirable for lower-end homes. One possible explanation is that the additional landscaping and maintenance of a larger lot size puts off homebuyers in this price range.

The remaining variables in this model take the expected signs. Our results suggest houses with fireplaces and cedar roofs command 8% and 13% higher prices, respectively, and that each additional square foot of garage space increases house price by about 0.05%. These estimates are all significant at the 1% significance level. The year dummies also appear to capture the decline in

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[21] Sirmans and Macpherson (2003) provide a summary of coefficient estimates from previous hedonic pricing model studies including the number of times coefficients were positive, negative, and insignificant.

the housing market we expect to see during this time period. The $attached\_carportsf_i$ and $year\_built_i$ variables are not significant in this regression at the 10% level. Based on these results we proceed to add our street variables in subsequent sections.

Hedonic Regression: SCI

Our second regression analyzes the effect of the SCI variable on house sales price, using the street classification and pavement type as control variables. Although this regression also provides coefficient estimates for the $asphalt_i$ and $improved_i$ variables in relation to their respective reference categories (i.e. $gravel_i$ and $unimproved_i$), we do not attempt to draw conclusions from them here due to evidence of multicollinearity between the $asphalt_i$ and $improved_i$ variables[22]. Regression 2 is as follows:

(2) $lprice_i = \beta_0 + \beta_1 lacres_i + \beta_2 no\_bedrooms_i + \beta_3 no\_fullbaths_i + \beta_4 no\_halfbaths_i + \beta_5 year\_built_i + \beta_6 eff\_year\_built_i + \beta_7 total\_finish\_sqft_i + \beta_8 attached\_garsf_i + \beta_9 attached\_carportsf_i + \beta_{10} roof\_cedar\_wood_i + \beta_{11} fireplace_i + \beta_{12} y2_i + \beta_{13} y3_i + \beta_{14} y4_i + \beta_{15} y5_i + \beta_{16} y6_i + \beta_{17} y7_i + \beta_{18} asphalt_i + \beta_{19} improved_i + \beta_{20} SCI_i + \varepsilon_i$

The coefficient estimates for the control variables in this regression show little change from Regression 1[23]. Table 4 shows the estimates for our street variables.

Table 4: OLS Estimates - SCI for Dependent Variable Natural Log of Sale Price

STREET VARIABLES	
asphalt	0.135*
	(0.0812)
improved	0.0642
	(0.0577)
sci	-0.00193*
	(0.00108)
Observations	439
R-squared	0.432
F	24.14
Robust standard errors in parentheses	
*** p<0.01, ** p<0.05, * p<0.1	

---

[22] To test for multicollinearity we regressed the street variables in question on one another and analyzed the R-squared and F-Stat values. We also calculated the pair-wise correlation between the variables, looking for a correlation coefficient of above 0.8 to suggest multicollinearity.

[23] See Appendix A for full regression results.

Our variable of interest in this regression is the sci_i variable, which yields a coefficient estimate of -0.00193. This coefficient estimate can be interpreted as suggesting a one-point increase in pavement condition results in an approximately 0.19% decrease in house price, on average, significant at the 10% level. This negative SCI coefficient is an unexpected result that may be attributable to our relatively small sample of home sales. Another potential explanation is that street pavement conditions are not very important for this group of homes as a whole and homebuyers may simply be paying more for homes with lower street pavement conditions due to an additional structural feature or neighborhood characteristic we are unable to control for with our data. However, it may also be the case that street conditions have different effects for more expensive homes, so we next estimate the effects of the SCI variable for different sales price thresholds.

Hedonic Regressions with SCI-Sale Price Interaction Variables

Although the data as a whole suggest the SCI variable has a negative or minimal effect on Springfield house prices, we also test whether the effects of pavement condition differ for ranges of house values. For these tests we create new indicator variables to denote house prices above certain thresholds. We then interact these new sale price indicator variables with the SCI variable to test these threshold effects. A description of these variables is provided in Table 5.

Table 5: Description of New Variables

Variable	*Definition*
abovemean	Dummy variable indicating sale price above mean (=1 if above mean, =0 otherwise)
onebelowmean	Dummy variable indicating sale price greater than one standard deviation below mean (=1 if above, =0 otherwise)
oneabovemean	Dummy variable indicating sale price greater than one standard deviation above mean (=1 if above, =0 otherwise)
sci_abovemean	Interaction variable equal to sci*abovemean
sci_belowmean	Interaction variable equal to sci*belowmean
sci_oneabovemean	Interaction variable equal to sci*oneabovemean

We first analyze the effect of the interaction between SCI and house values above the mean sale price, which for our sample is approximately $178,384. We use the following form for this regression, as well as additional regressions using the SCI-sale price interaction variables:

$$\text{lprice}_i = \beta_0 + \beta_1\text{lacres}_i + \beta_2\text{no\_bedrooms}_i + \beta_3\text{no\_fullbaths}_i + \beta_4\text{no\_halfbaths}_i + \beta_5\text{year\_built}_i + \beta_6\text{total\_finish\_sqft}_i + \beta_7\text{attached\_garsf}_i + \beta_8\text{attached\_carportsf}_i + \beta_9\text{roof\_cedar\_wood}_i + \beta_{10}\text{fireplace}_i + \beta_{11}\text{y2}_i + \beta_{12}\text{y3}_i + \beta_{13}\text{y4}_i + \beta_{14}\text{y5}_i + \beta_{15}\text{y6}_i + \beta_{16}\text{y7}_i + \beta_{17}\text{asphalt}_i + \beta_{18}\text{improved}_i + \beta_{19}\text{SCI}_i + \beta_{20}\text{abovemean}_i + \beta_{21}\text{sci\_abovemean}_i + \varepsilon_i \tag{3}$$

Estimates for our street variables of interest are provided in Table 6 and full regression results are provided in Appendix B.

Table 6: OLS Estimates - SCI-Sale Price Interactions for Dependent Variable Natural Log of Sale Price

EXPLANATORY VARIABLES	Above Mean	> One S.D. Below Mean	> One S.D. Above Mean
asphalt	0.0866	0.0604	0.121
	(0.0719)	(0.0473)	(0.0743)
improved	0.0444	-0.00599	0.0684
	(0.0459)	(0.0315)	(0.0493)
sci	-0.00350***	-0.00453*	-0.00199**
	(0.00118)	(0.00269)	(0.00101)
abovemean	0.327***		
	(0.0591)		
sci_abovemean	0.00419***		
	(0.00132)		
onebelow		0.772***	
		(0.100)	
sci_onebelow		0.00514*	
		(0.00263)	
oneabove			0.997***
			(0.229)
sci_oneabove			-0.00727*
			(0.00391)
Observations	439	439	439
R-squared	0.592	0.759	0.537
F	34.94	33.53	26.99

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

By focusing on the sci_abovemean_i interaction variable, we are able to estimate the impact of street pavement conditions for houses with above average sale prices. This new interaction term yields a positive coefficient estimate of 0.00419 and is significant at the 1% level. To interpret the effect of this interaction term on our dependent variable, we also add the coefficient on the SCI variable to obtain their cumulative effect for homes above the mean sale price. Doing so yields a new estimate of 0.00069. This suggests that for homes with above-average sale prices, a one-point increase in SCI leads to an approximately 0.07% increase in house value, on average. All else held constant, this means for a house with a sale price of $178,384, raising the street's SCI pavement quality rating by one standard deviation, or 23.41 points, raises the sale price by $2,923, on average.

Based on these findings, we next examine a threshold for sale prices greater than one standard deviation below the mean price. This corresponds to house values greater than $97,466. To estimate this regression, we substitute the onebelow_i and sci_onebelow_i variables for the abovemean_i and sci_abovemean_i variables in Regression 3. The SCI interaction coefficient estimate from this regression also indicates positive benefits from better pavement quality, significant at the 10% level. However, the effect to homeowners of better pavement drops to approximately 0.06% for each one-point increase in SCI rating. Thus, a one standard deviation increase in SCI results in a smaller gain of approximately $2,506, on average, for a home with a sale price of $178,384.

However, when homes do not meet the minimum sale price threshold of $97,466, we determine the effect of SCI by ignoring the sci_onebelow_i interaction variable and looking solely at the estimate for the sci_i variable. Here, the sci_i variable suggests the effect of a one-point increase in SCI rating results in a 0.45% decrease in sale price, significant at the 10% level. Similarly, using a threshold for properties with sale prices at least one standard deviation above the mean leads to a negative coefficient on both the sci_i and sci_oneabove_i variables. Based on this estimate, houses with a sale price above $259,301 lose approximately 0.93% in value, on average, for each one-point increase in SCI. This is significant at the 10% level. Taken together, these results seem to suggest that properties with values on the high and low ends of the sample are somehow different from those properties with values near the mean sale price. This could be attributable to omitted variables, which are causing a downward bias on the coefficient estimates, or it could be due to having fewer observations in these ranges.

Our results from interacting the SCI pavement condition variable with different minimum sale price thresholds indicate some positive benefits from improved street pavement quality may exist. Specifically, homes with values that fall around the mean in our sample seem to command the greatest increases in sale prices due to better pavement condition. Although, homes with sale prices on the high and low ends of our sample appear to see negative results from better street pavement, we hesitate to draw any firm conclusions about these houses due to our relatively small sample of properties. It is also important to note again that we view these effects as upper estimates of the true effects due to the lack of randomization and potential upward bias in our data.

Hedonic Regressions: Gravel to Asphalt and Unimproved to Improved

We next consider the impact of paving a gravel street and upgrading unimproved streets to fully improved streets. To do so, we use the following regression form:

(4) $lprice_i = \beta_0 + \beta_1 lacres_i + \beta_2 no\_bedrooms_i + \beta_3 no\_fullbaths_i + \beta_4 no\_halfbaths_i + \beta_5 year\_built_i + \beta_6 total\_finish\_sqft_i + \beta_7 attached\_garsf_i + \beta_8 attached\_carportsf_i + \beta_9 roof\_cedar\_wood_i + \beta_{10} fireplace_i + \beta_{11} y2_i + \beta_{12} y3_i + \beta_{13} y4_i + \beta_{14} y5_i + \beta_{15} y6_i + \beta_{16} y7_i + \beta_{17} sci_i + \beta_{18} asphalt_i + \varepsilon_i$

where the $asphalt_i$ variable is swapped for the $improved_i$ variable to estimate the impact of having an improved street. As previously mentioned, we do not include the street classification and surface variables simultaneously in these regressions due to multicollinearity issues.

For both regressions, we find positive effects from asphalt pavement and fully improved streets[24]. As shown in Table 7, the coefficient estimate for the asphalt dummy variable is 0.1616, suggesting an asphalt street surface commands a 16% higher sale price compared to a gravel surface, on average. This is significant at the 5% level. The coefficient estimate for the $improved_i$ variable is 0.0910, suggesting an increase in sale price of about 9%, on average, from moving to a fully improved street[25]. However, this effect is not quite significant at 10% level. These results suggest the most significant private benefits may result from paving gravel streets, which make up 6.6% of the streets in our sample. The asphalt effect we see here also seems to fall in line with the results found in Gonzalez-Navarro and Quintana-Domeque (2010).

Table 7: OLS Estimates - Gravel to Asphalt and Unimproved to Improved for Dependent Variable Natural Log of Sale Price

EXPLANATORY VARIABLES	Gravel to Asphalt	Unimproved to Improved
sci	-0.00129*	-0.00169
	(0.000754)	(0.00109)
asphalt	0.162**	
	(0.0794)	
improved		0.0910
		(0.0564)
Observations	439	439
R-squared	0.430	0.428
F	25.31	25.61

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[24] See Appendix C for full regression results.

[25] Due to very low numbers of partially improved streets in our sample, we combined partially improved streets with unimproved streets in the reference category to estimate the effect of a fully improved street.

Robust standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Cost-Benefit Analysis

Based on the positive benefits associated with better pavement quality for different thresholds, as well as the positive benefits of paving gravel streets, we conduct a cost-benefit analysis for the average homeowner. Our goal is to show the private, monetary benefits an individual homeowner might expect to receive in relation to the overall expenditure needed to finance the project.

To calculate private benefits for individual homeowners we use the mean house price for each threshold range in which we found statistically significant positive effects. This amounts to $247,205 for the threshold set at above the mean and $190,178 for the threshold greater than one standard deviation below the mean. We use the sample mean of $178,384 to calculate the average benefits from paving a gravel street. We also calculate the average benefit from a fully improved street using the $178,384 sample mean because it is very close to being significant at the 10% level and could be significant in a sample with more unimproved and partially improved street observations. To calculate the cost for an average homeowner, we use the City of Springfield's cost estimate of $450 per linear foot, as well as the average segment length attributable to each homeowner, which is approximately 51.8 linear feet. It is important to note that the $450 per linear foot cost estimate represents the cost for fully improving a local street, so actual costs may be lower if less expensive maintenance or improvements are performed. Thus, our cost estimate should be viewed as an upper bound for the cost to the average homeowner.

Based on these assumptions and our regression estimates in Sections 7.3 and 7.4, we calculate the total costs and private homeowner benefits reported in Table 8[26]. We also report any excess cost or excess private benefit from these improvements.

Table 8: Cost-Benefit Analysis - Private Benefits vs. Total Costs

	Avg. Private Benefit per Homeowner	Avg. Total Cost per Homeowner	Excess Cost/Benefit	% of Total Cost
> Mean	$7,983.00	$23,310.00	-$15,327.00	34%
> One S.D. Below Mean	$5,429.00	$23,310.00	-$17,881.00	23%
Gravel to Asphalt	$28,720.00	$23,310.00	$5,410.00	123%
Unimproved to Improved	$16,625.00	$23,310.00	-$6,685.00	71%

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[26] These results are shown graphically in Figure 5.

We find that for the above mean threshold, the private benefits to the average homeowner, as measured by the increase in house sale price, are only 34% of total costs. Similarly, for the lower threshold of one standard deviation below the mean, the average private benefits per homeowner recover only 23% of average total costs for this larger range of houses. Based on these calculations a gap between private benefits and total construction costs of $15,327 to $17,881 exists.

This clearly indicates that even optimistic estimates of private homeowner benefits do not exceed the total project costs. Thus, for these local street improvements to make sense from an economic perspective, the total public benefits must at least be great enough to make up the $15,327 to $17,881 difference between private benefits and total costs. These public benefits could come from things like improved street safety or even the ability to attract new residents and businesses by offering more desirable living conditions. If public benefits are large enough to offset the difference between private benefits and total cost, this would be consistent with the theory we outline in Section 3.3. In this case, if the City wants to encourage local street improvements, it should strongly consider public funding to cover the portion of total cost in excess of private benefits. However, if the additional public benefits are not large enough to make up this difference, then the theory outlined in Section 3.1 would hold and it does not make economic sense for the City or homeowners to fund these street improvements. One potential way to gauge the amount of additional public benefit that exists would be to propose an increase to the City's gas tax that would use the additional revenue to fund these improvements. In theory, if the public benefits are large enough to make up the cost, voters' willingness to pay additional taxes should reflect these benefits.

Where our results suggest private benefits may outweigh private costs is in paving gravel roads. Here we estimate private benefits to be 123% of the total project costs, on average, suggesting this may be the most beneficial improvement to individual homeowners. Again, this should be viewed as an optimistic estimate of the private benefit, but our result indicates that one of the theories outlined in Sections 3.2, 3.4, or 3.5 may best explain homeowners' current response to the City's street improvement policy. This could include some type of information or coordination failure, a lack of homeowner liquidity to fund the project, or some combination of these factors.

Although upgrading an unimproved street to a fully improved street is not quite statistically significant at the 10% level, we report the result here since the t-statistic is very close to the cutoff and the estimate may still prove useful in considering the City's policy options. Based on our results, the private benefit of improving an unimproved street to a fully improved street is approximately 71% of the total cost. This estimate again suggests some additional public benefit must exist to make this improvement economically feasible for all stakeholders.

Conclusion

This study applies a hedonic pricing model to single-family residences in Springfield, Oregon to analyze the impact of local street condition and street improvements on residential house prices between 2006 and 2012. It then uses the resulting estimates to conduct a cost-benefit analysis for the average homeowner. The ultimate goal of this analysis is to determine why local streets have remained unimproved despite deteriorating street conditions during this time period.

The principal findings of our study are that better street pavement corresponds to higher sale prices, but the benefits are most pronounced for homes sold above minimum price thresholds. In addition, our statistical analysis finds that the most significant homeowner benefits result from paving gravel streets. Using the results from our statistical models, our cost-benefit analysis indicates that private benefits from local street improvements are not large enough to offset total construction costs, with the exception of paving gravel streets. Based on these findings, we conclude that for these street improvement projects to be economically beneficial for all stakeholders there must exist enough public benefits to make up the difference between the private benefits and total project costs. And in the event large enough public benefits can be identified, the City of Springfield should consider ways to publically finance the remaining costs in order to achieve an efficient outcome.

While the results of our study shed light on potential private benefits for Springfield homeowners, our study could be improved with more data and better randomization of street selection using an experimental process like that outlined in Gonzalez-Navarro and Quintana-Domeque (2010). Also, the primary focus of our study was the impact of street surface condition on house prices. A more complete picture of the private benefits of a fully improved local street could be gained by looking in more detail at the additional amenities of a fully improved local street including the combined effects of things like street trees, street lights, and traffic control devices.

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Figure 1: Local Street Conditions - Good, Fair, Poor

Figure 2: Total Lane Miles by Functional Classification

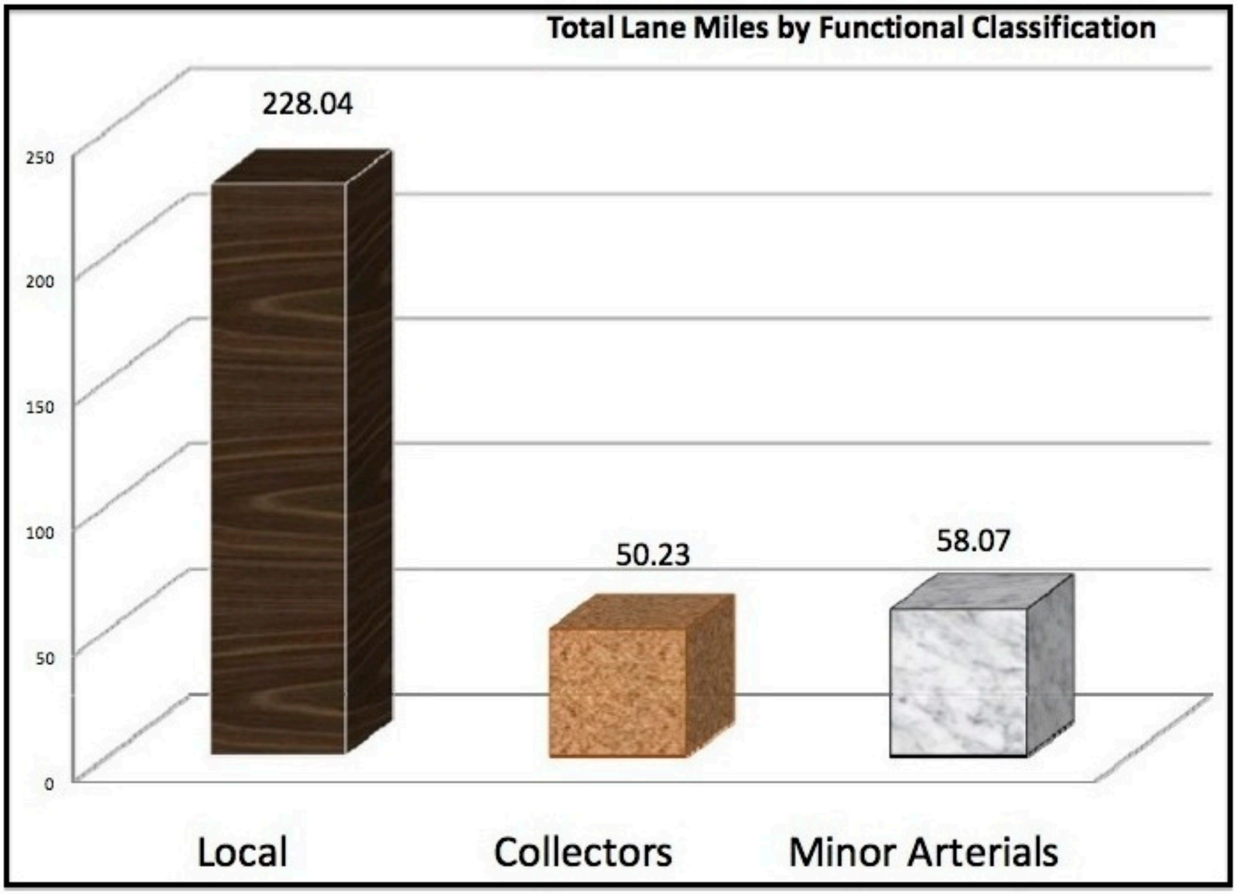


Figure 3: Examples of Pavement Defect Types

Raveling

Cracking

Base Failure

Figure 4: Springfield Street Network by Surface Type with Outline of Study Area

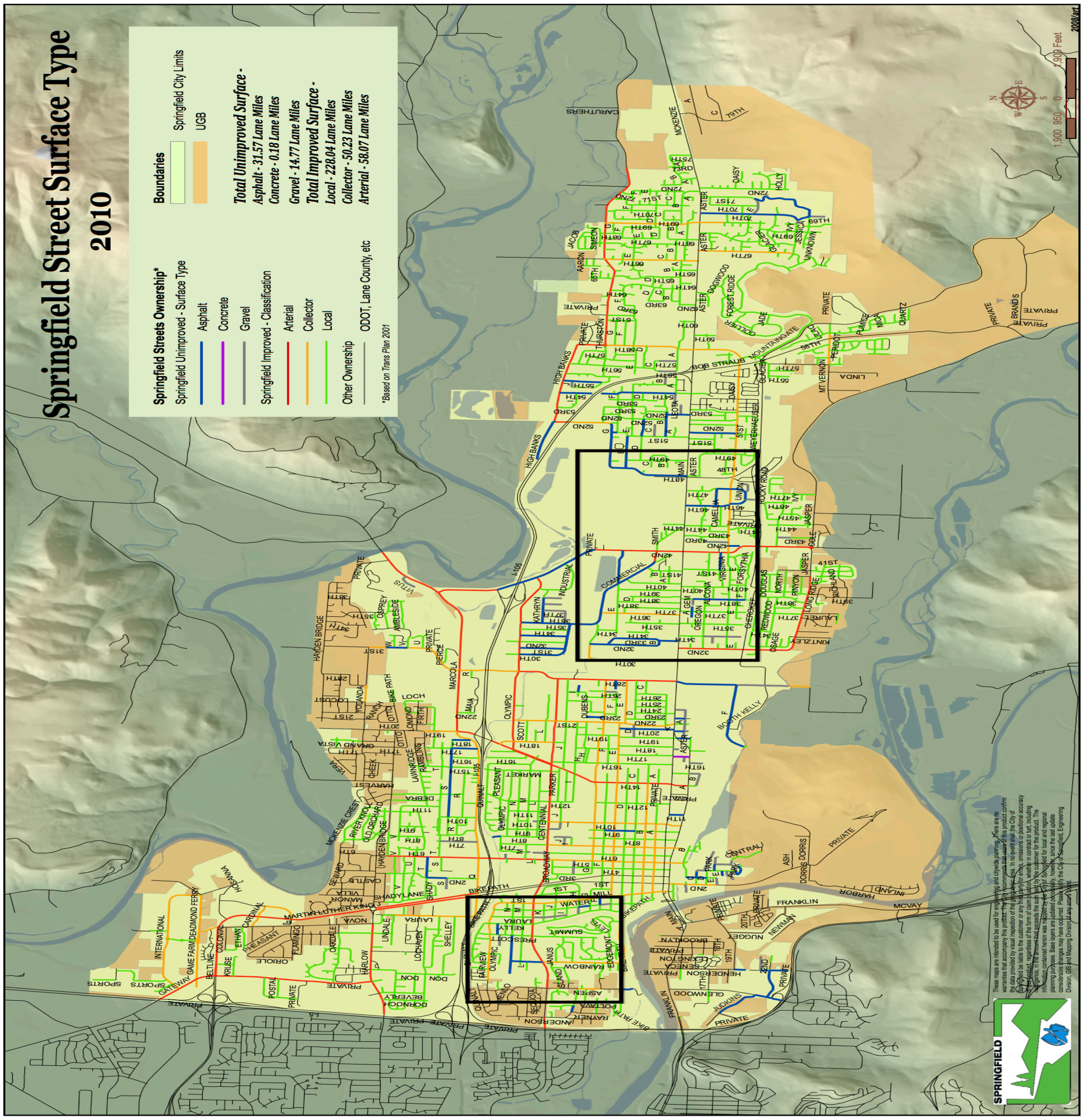
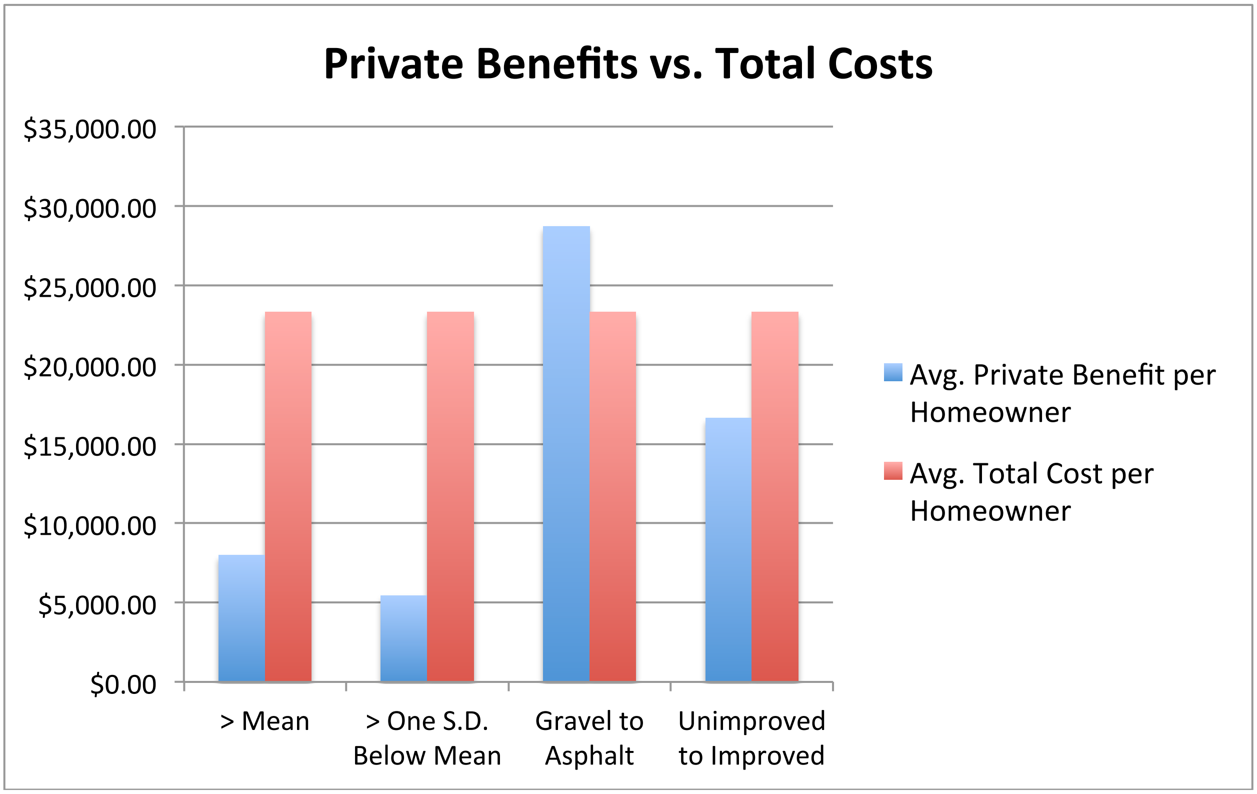


Figure 5: Private Benefits vs. Total Costs for Street Improvement Types



Appendix A: OLS Estimates with Control Variables - SCI for Dependent Variable Natural Log of Sale Price

STREET VARIABLES	
lacres	-0.146***
	(0.0532)
no_bedrooms	-0.113***
	(0.0375)
no_fullbaths	-0.00388
	(0.0596)
no_halfbaths	-0.124*
	(0.0680)
total_finish_sqft	0.000515***
	(7.41e-05)
year_built	0.000168
	(0.00154)
attached_garsf	0.000528***
	(0.000114)
attached_carportsf	-0.000339
	(0.000364)
roof_cedar_wood	0.142***
	(0.0463)
fireplace	0.0782***
	(0.0282)
y2	0.0654*
	(0.0349)
y3	-0.0119
	(0.0375)
y4	-0.287***
	(0.0627)
y5	-0.141**
	(0.0571)
y6	-0.386***
	(0.0585)
y7	-0.478***
	(0.0852)
asphalt	0.135*
	(0.0812)
improved	0.0642
	(0.0577)
sci	-0.00193*
	(0.00108)
Constant	10.90***

	(2.999)
Observations	439
R-squared	0.432
F	24.14

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix B: OLS Estimates with Control Variables - SCI-Sale Price Interactions for Dependent Variable Natural Log of Sale Price

EXPLANATORY VARIABLES	Above Mean	One S.D. Below Mean	One S.D. Above Mean
lacres	-0.125***	-0.0418	-0.126**
	(0.0416)	(0.0325)	(0.0489)
no_bedrooms	-0.102***	-0.0615**	-0.0565*
	(0.0324)	(0.0261)	(0.0322)
no_fullbaths	-0.0843*	-0.000700	0.0261
	(0.0486)	(0.0353)	(0.0540)
no_halfbaths	-0.100*	-0.0261	-0.0903
	(0.0524)	(0.0367)	(0.0598)
total_finish_sqft	0.000356***	0.000463***	0.000200***
	(5.76e-05)	(4.50e-05)	(7.24e-05)
year_built	-0.00138	0.000229	-8.67e-05
	(0.00129)	(0.000894)	(0.00135)
attached_garsf	0.000362***	0.000289***	0.000391***
	(8.35e-05)	(6.01e-05)	(9.03e-05)
attached_carportsf	-0.000594	0.000308	-0.000377
	(0.000419)	(0.000197)	(0.000362)
roof_cedar_wood	0.0409	0.0821**	0.0977*
	(0.0347)	(0.0342)	(0.0502)
fireplace	0.0213	-0.0112	0.0722***
	(0.0258)	(0.0205)	(0.0271)
y2	0.00726	0.0446**	0.0548*
	(0.0316)	(0.0221)	(0.0310)
y3	0.0215	-0.0220	-0.0325
	(0.0360)	(0.0294)	(0.0344)
y4	-0.145***	-0.140***	-0.267***
	(0.0489)	(0.0368)	(0.0565)
y5	-0.0741	-0.0826**	-0.183***
	(0.0521)	(0.0359)	(0.0529)
y6	-0.152**	-0.247***	-0.340***
	(0.0589)	(0.0457)	(0.0522)
y7	-0.325***	0.0193	-0.485***
	(0.101)	(0.125)	(0.0874)
asphalt	0.0866	0.0604	0.121
	(0.0719)	(0.0473)	(0.0743)
improved	0.0444	-0.00599	0.0684
	(0.0459)	(0.0315)	(0.0493)
sci	-0.00350***	-0.00453*	-0.00199**
	(0.00118)	(0.00269)	(0.00101)

abovemean	0.327***		
	(0.0591)		
sci_abovemean	0.00419***		
	(0.00132)		
onebelow		0.772***	
		(0.100)	
sci_onebelow		0.00514*	
		(0.00263)	
oneabove			0.997***
			(0.229)
sci_oneabove			-0.00727*
			(0.00391)
Constant	14.23***	10.25***	11.63***
	(2.512)	(1.729)	(2.629)
Observations	439	439	439
R-squared	0.592	0.759	0.537
F	34.94	33.53	26.99

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix C: OLS Estimates with Control Variables - Gravel to Asphalt and Unimproved to Improved for Dependent Variable Natural Log of Sale Price

EXPLANATORY VARIABLES	Gravel to Asphalt	Unimproved to Improved
lacres	-0.145***	-0.159***
	(0.0531)	(0.0536)
no_bedrooms	-0.113***	-0.113***
	(0.0378)	(0.0377)
no_fullbaths	-0.00207	-0.0101
	(0.0592)	(0.0590)
no_halfbaths	-0.126*	-0.127*
	(0.0685)	(0.0680)
total_finish_sqft	0.000510***	0.000525***
	(7.47e-05)	(7.45e-05)
year_built	0.000198	0.000179
	(0.00154)	(0.00154)
attached_garsf	0.000545***	0.000529***
	(0.000118)	(0.000114)
attached_carportsf	-0.000345	-0.000372
	(0.000372)	(0.000355)
roof_cedar_wood	0.136***	0.147***
	(0.0447)	(0.0461)
fireplace	0.0811***	0.0758***
	(0.0279)	(0.0288)
y2	0.0664*	0.0723**
	(0.0353)	(0.0347)
y3	-0.0159	0.000445
	(0.0369)	(0.0374)
y4	-0.285***	-0.281***
	(0.0627)	(0.0630)
y5	-0.139**	-0.139**
	(0.0572)	(0.0587)
y6	-0.382***	-0.378***
	(0.0595)	(0.0578)
y7	-0.466***	-0.487***
	(0.0851)	(0.0810)
sci	-0.00129*	-0.00169
	(0.000754)	(0.00109)
asphalt	0.162**	
	(0.0794)	
improved		0.0910
		(0.0564)
Constant	10.84***	10.95***

	(2.984)	(2.985)
Observations	439	439
R-squared	0.430	0.428
F	25.31	25.61

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1