Valuing Green Roof's Effect on Commercial Property Rents: A Two Stage Least Squared Approach[1]

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Abstract:

Due in part to the multiple benefits greens roofs provide, implementation of green roof systems continues to rise across urban areas including cities like Washington, DC. Underlying the spread of green roofs are trends toward dense, clean, and livable urban developments and enhanced building performance. Employing a hedonic price method and a spatial two-stage least squared estimation, we find that green roofs have a significant effect on the tradable value of commercial property rent in the Washington, DC real estate market. Green roofs have approximately a 15% effect on the value of rent per square foot office buildings in Washington, DC in comparison with other buildings in the same market. These findings are consistent with previous research on the economic value of green roofs including Ichihara and Cohen (2010, DOI 10.1007/s12076-010-0046-4) who found that multi-family residential buildings with green roofs collected about 16% higher on average rents than those without green roofs in New York City.

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INTRODUCTION

There are clear public benefits to installing green roofs[2] on buildings. Green roofs mitigate harmful air pollution by reducing particulate matter such as "*nitrogen oxide, sulfur dioxide, carbon monoxide, and ground-level ozone*" (Foster, Lowe, & Winkleman, 2011). They reduce the impervious surface area of buildings by detaining 90% water volume for storms less than one inch and at least 30% for larger storms (Foster, Lowe, & Winkleman, 2011). Green roofs have been found to reduce surface temperature by 30-60°C and ambient temperature by 5°C (Foster, Lowe, & Winkleman, 2011). The insulation properties of green roofs reduce ambient noise by two to eight decibels (Foster, Lowe, & Winkleman, 2011) and roof-top green space improves biodiversity and the aesthetics of a building and the surrounding urban area (Getter & Rowe, 2006). Additionally, the enhanced natural environment has been found to improve tenant health and worker productivity by decreasing stress levels (Kaplan, 1988).

Due in part to a rising trend of urbanization and a better understanding of how the built environment affects nature and human well-being (Clark, Adriaens, & Talbot, 2008), the past 20 years have seen an increase in green infrastructure technology including green roofs in the global building sector (Foster, Lowe, & Winkleman, 2011). In this time, Washington, DC has become the nation's largest market for green roofs according to a Green Roofs for Healthy Cities survey[3].

Washington, DC has made deliberate policy decisions to reduce the amount of stormwater run-off that have impaired nearby Anacostia and Potomac Rivers, Rock Creek, and Chesapeake Bay for decades. In its Vision for a Sustainable DC (2012) the District of Columbia Office of Planning lists one of its top goals is an increase in the number of green roofs in the city.

Beyond a driven public sector, for property owners and investors the evidence is mounting that green roofs are good for the bottom-line. Examining LEED and Energy Star certified buildings, Miller, Spivey, & Florance (2008) found that employing green infrastructure in buildings adds to property value and higher rents. Longevity and energy reduction benefits give buildings with green roofs a net present value advantage (Clark, Adriaens, & Talbot, 2008). Green roofs have been found to protect the roof membrane from wind, UV radiation, and dramatic temperature variance that can increase the lifetime of the roof by up to three times (Foster, Lowe, & Winkleman, 2011). Green roofs also insulate buildings in the winter and cool them in the summer leading to energy savings between 15-45% annually (Foster, Lowe, & Winkleman, 2011).

Despite the promising trends, only a handful of revealed preference studies examining the effect green infrastructure has on rent and property values have been conducted. In one examining multi-story residential properties in New York City, Ichihara and Cohen (2010) found those buildings with green roofs collected about 16% higher average rent than those without green roofs. Similarly using hedonic methods on property values, Tomalty and Komorowski (2010) found the benefits of green infrastructure had positive increase on property values; increasing values as high as 11% over properties without green infrastructure.

Collections of information about green roof infrastructure are more available today since the Department of Energy and other governmental agencies require the measurement of storm-water

[2] For purposes of this study, a green roof is the roof of a building that is partially or completely covered with vegetation and planted over a waterproof membrane.
[3] http://www.greenroofs.org/index.php/resources/2012-green-roof-industry-survey accessed on June 30, 2013

capture for regulatory requirements. Using these newly available data sources, research that investigates the extra value green infrastructure generates could provide valuable information for the building and property owners to consider when thinking about return on investment for green infrastructure.

In the hedonic analysis performed in this paper, we used a compilation of factors from studies completed for both residential and commercial evaluation of property values, i.e. rental rates. In addition to some of the variables discussed in the previously mentioned studies, we also examined the impact of spatial data such as distance to toxic sites (Carruthers & Clark, 2010), physical characteristics such as building age, and additional amenities that have been used in other hedonic property valuation models (Dunse & Jones, 1998). For this study, we examined over 100 variables and filtered down to 44 that were most suitable.

RESEARCH OBJECTIVE AND APPROACH

The objective of this economic analysis is to determine the effect that having a green roof has on commercial rent in office buildings in Washington, DC after controlling for other value determinants.

Data Sources

To determine the impact green roofs have on the commercial value of office buildings, we retrieved data on rent and amenities from the CoStar Real Estate database (accessed on November 12, 2012), information on green roofs from Washington, DC District Department of Energy (DDOE), and spatial variables that the authors computed using data gathered from the District of Columbia Government's GIS data clearinghouse, Data.DC.Gov. Borrowing from Oven and Pekdemir (2006) we used and categorized independent variables into four groups and listed with their source:

Table 1: Hedonic Model Data and Source

<table>
<tr><td>Location Determinants
- Distance to Metro (computed)
- Distance to K Street NW (computed)
- Distance to Primary and Secondary Streets (computed)
- Distance to White House (computed)
- Distance to Toxic Waste Sites (computed)
- Walking Time to Transit (CoStar)
- Number of Reported Crimes within 0.2 mile (DCMPD, computed)
- Number of Stories (CoStar)
- Submarket Cluster (CoStar)</td><td rowspan="3">Building Determinants
- Age of Building (CoStar)
- Number of Floors (CoStar)
- Number of Elevators CoStar)
- Total available space (CoStar)
- Number of Parking Spaces (CoStar)
- Green Roof Dummy (District Department of Energy)
- Green Roof Square Foot Coverage (DDOE)
- Parcel Land Area (CoStar)
- Construction Material (CoStar)
- LEED Certification (CoStar)
- Bank (CoStar)
- Energy Star Certified (CoStar)
- Conference Room (CoStar)
- Number of Elevators (CoStar)
- Restaurant (CoStar)
- Maximum Contiguous Space in Building (CoStar)
- Maximum Contiguous Space on Floor (CoStar)
- Year Last Renovated (CoStar)
- Mixed Use Development (CoStar)
- 24/7 Access (CoStar)</td></tr>
<tr><td>Econometric Determinants
- Percent Office Space Leased (CoStar)</td></tr>
<tr><td>Contract Determinants
- Direct Available Space (CoStar)
- Direct Vacant Space (CoStar)
- Tax Per Square Foot using 2012 USD$ (CoStar)
- Rentable Building Area (CoStar)</td></tr>
</table>

- Property Manager onsite (CoStar)	- Courtyard (CoStar) - Food court (CoStar) - Mail Room (CoStar)

Dependent Variable: Natural Log of Average Weighted Rent

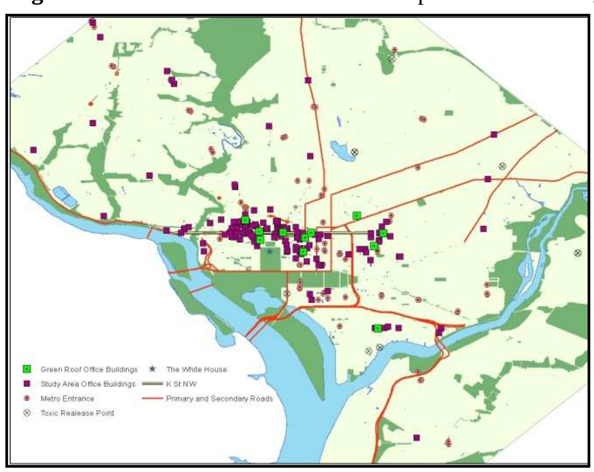
We followed recent hedonic price researchers who examined an environmental factor's impact on commercial value (Debrezion, et al 2007; Ichihara & Cohen 2011; Cohen & Coughlin 2008; Carruthers & Clark 2010) by choosing the natural log of rent as our dependent variable. More specifically, we use the log of *average weighted rent* since the average weighted rent is the most widely available and accurate market rate of rent data available in Washington, DC.

To calculate average weighted rent, property owners reporting to CoStar provide their average rental rate for units in a given building. Since the size of the space available will skew the average rate for a building a weighted average called the average weighted rent has been generated (the larger the space, the more that particular rental rate counts in the average). CoStar calculates the average weighted rent by *"multiplying the square footage of each unit by its asking rental rate to obtain the total asking rent for each space, then totaling the rents for each space and dividing that sum by the total square footage for all units."*[4] Negotiable rental rates and rental rates of zero are excluded in this calculation.

Descriptive Statistics of Variables

The sample size of this economic analysis includes 141 office buildings in the Washington, DC real estate market with an average weighted rent of $44.04 per square foot. Eleven of the 141 office buildings have green roofs (7.7%) and together they have an average weighted rent of $48.12 per square foot. For additional summary details on the variables see the data appendix.

Figure 1: Location Determinants and Sample Office Buildings



Data Limitations

The model we used could be strengthened with additional contract determinant variables such as duration of contract (Brennan et al., 1984; Wheaton and Torto, 1994) and operational expenses (electricity, water, gas, security etc.) (Shilling, et al., 1987) that have been used in past office rent hedonic studies. Additional regional econometric variables could strengthen the model such as average un-let duration of offices in the region (Wheaton and Torto, 1994), annual depreciation rate of the building (Hendershott, 1996) and growth in employment in the region (Glasscock et al., 1990). Finally, the model would be strengthened by additional information on the green roof infrastructure. For example, green roof type (intensive or extensive), roof top garden amenities (patio, sky garden, agriculture, etc) and storm-water retention capacity would add depth to the model that may not appear significant.

SPATIAL TWO STAGE LEAST SQUARED REGRESSION MODEL

[4] http://www.costar.com/about/glossary.aspx?hl=A

We used a spatial two stage least squared regression analysis (2SLS) to determine the impact green roofs have on average weighted rents.

The first stage of the regression equation can be written as the following:

$log\ (average\ weighted\ rent)_i = \beta_0 + \beta_1(Green\ Roof)_i + \beta_2(Number\ of\ Stories)_i + \beta_3(Walking\ time\ to\ transit)_i + \ldots\beta_n X_n + \varepsilon_i$

$y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots\beta_n X_n + \varepsilon_i$

Where y_i is the estimated value for the average weighted rent for the observation i, β_0 is the intercept, $\beta_{i,}$ is the coefficient for the independent variable X_i listed and ε_i is a normally distributed error term and the subscripts ($_i$) refer to the different office buildings in the sample dataset where $_i$ = 1, 2, 3, 4….142 since there are n=142 office buildings in our dataset.

Since the error term ε_i is endogenous or correlated to the estimated value of average weighted rent y_i for each observation in the first stage OLS, we must perform a second regression using instrumental variables. The instrumental variables used were developed based on a weighted matrix of the four nearest neighbors for each independent variable. The predicted value of the dependent variables for each observation from the first stage OLS regression are then regressed against the values of the independent variables obtained from the weighted matrix of the four nearest neighbors. The new results of this regression are used as the final estimators of the dependent variable (the average weighted rent). By performing this 2SLS regression analysis, we eliminated the bias caused by the error term estimated in the first OLS because of its endogeneity to the estimated value of the average weighted rents.

RESULTS

The coefficient on the green roof dummy variable was approximately 0.15 at a confidence level greater than 99.9 percent. Using the interpretation from Halvorsen and Palmquist (1980), the coefficient represents the percentage of the average weighted rent estimate that is a result of the green roof on the building. In other words, we can say that having a green roof has an effect of 15% on the average weighted rent. Therefore, the model shows that with 99.9% confidence, those units in office buildings with a green roof rent for 15% higher than those without green roofs with all other variables held constant.

Table 2: Significant Regression Results

Dependent Variable: Log Average Weighted Rent

Method: Spatial Two Stage Least Squares

Observations: 141

Instrumented Variable: Weighted Log Average Weighted Rent

Variable	*Coefficient*	*Std. Error*	*z-statistic*	*Prob.*
Constant	3.918922	0.2460891	15.92	0.001
Green Roof (dummy)	0.1499186	0.0224144	6.69	0.001

Square Foot of Green Roof	-0.00000449	0.00000176	-2.55	0.011
Square of Building Age	0.00000285	0.000000605	4.71	0.001
Office Building Class B (dummy)	0.5224434	0.0329212	15.87	0.001
Office Building Class A (dummy)	0.6626308	0.0356925	18.56	0.001
Walk Time to Transit	0.0037072	0.0013146	2.82	0.005
Energy Star Building (dummy)	0.0397687	0.0086299	4.61	0.001
Steel Construction Material (dummy)	0.0384105	0.0098444	3.90	0.001
Log Direct Available Space	0.0328591	0.0100657	3.26	0.01
Log Max Contiguous Building Space	-0.0667479	0.0123576	-5.40	0.001
Log Max Contiguous Floor Space	0.0833892	0.0144243	5.78	0.001
LEED Gold Certified (dummy)	-0.0355799	0.0156205	-2.28	0.023
Log Percentage Leased	.0406543	0.0087017	4.67	0.001
Log Rentable Area	-0.0808281	0.0120758	-6.69	0.001
Capitol Hill Submarket (dummy)	0.1933504	0.0388367	4.98	0.001
Downtown Submarket (dummy)	0.2197898	0.0371434	5.92	0.001
Log Taxes per Square Foot	-0.0433689	0.010151	-4.27	0.001
Total Available Space	0.00000109	0.00000018	6.04	0.001
Year Renovated	-0.0130666	0.0029229	-4.47	0.001
Distance to Toxic Release Site	1.583048	0.6694108	2.36	0.018
Distance to K Street	-2.614566	0.4590649	-5.70	0.001
Log Crime within 0.2 miles	-0.0508547	0.0091107	-5.58	0.001
24 – 7 Hour Building Access (dummy)	-0.1451915	0.0114225	-12.71	0.001
Courtyard (dummy)	0.0239475	0.0117411	2.04	0.041
Corner Building (dummy)	0.0686856	0.0090456	7.59	0.001
Mixed Use (dummy)	0.4405441	0.0592214	7.44	0.001
Restaurant (dummy)	0.0376312	0.0098223	3.83	0.001
Food Court (dummy)	0.0698677	0.0173711	4.02	0.001
Mailroom (dummy)	0.0919001	0.0169058	5.44	0.001

R-squared	0.9667

29 out of 43 variables regression measured statistically significant and the direction of the results is mostly consistent with expected trends. For example, the model shows that as the maximum contiguous floor space for a unit increases, the effect on rent trends positive; and as the taxes per square foot increase the amount of rent collected goes down. These signs, along with an R-Squared value of approximately 97%, indicate perhaps an overly strong fit for the model.

DISCUSSION

The results from the hedonic price analysis show that property owners in the Washington, DC commercial real estate market could collect approximately 15% higher rents from their tenants if they installed a green roof. From a revenue standpoint, as more green roofs are applied to office buildings in the Washington, DC real estate market, the opportunity exists to capture possibly tens of billions of dollars of increased rents annually.

While this paper is intended to determine the benefits of installing green roofs in terms of increased value on rents, it does not measure the other benefits associated with green roofs discussed at the beginning of this study. The benefits of green roofs are tremendous, and this analysis helps inform property owners that there is financial incentive for installing a green roof system.

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