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Preface

We are pleased to present the ninth volume of the Journal of Sustainable Real Estate (JOSRE). This issue, prior issues, and other resources are available at www.josre.org.

This is our first publication under our new editorial team. We are grateful for Norm Miller, the journal’s founder and emeritus editor, for all he has done to help us transition.

The nine papers were rigorously vetted by a double-blind peer review process. We are pleased with the wide range of topics, methods, and geography covered in this issue. The goal to attract and nurture international papers as part of our journal’s mission has been met in the variety of countries represented by the authors and content of this volume.

The editors of JOSRE are dedicated to working with scholars in existing and emerging markets to produce high-quality papers to expand knowledge in the field of sustainability and the built environment.

Please view our call for papers for volume 10 located at the back of this publication, as well as on our website at http://www.josre.org/call-for-papers/.

Thank you to CBRE and Cleveland State University’s Maxine Goodman Levin College of Urban Affairs, our primary supporters.

Robert A. Simons
Senior Editor
Words from our Supporting Sustaining Industry Partner

CBRE is proud to support the *Journal of Sustainable Real Estate* in their mission to provide a platform for the publication of innovative research papers aimed at understanding and advancing the introduction and adoption of sustainable real estate practices.

We know that the built environment has a profound effect on the environment. We are also certain that with better knowledge comes better action. The work done by academic researchers gives confidence to the many stakeholders, especially investors and occupants, that the actions they are taking truly matter.

David L. Pogue
CBRE
LEED AP | Global Director of Corporate Responsibility
Measuring Long-term Effects of the Fukushima Daiichi Nuclear Power Plant Accident on Real Estate Prices

Authors Norifumi Yukutake and Satomi Sugawara

Abstract The Fukushima Daiichi Nuclear Power Plant accident was caused by the Great East Japan Earthquake in March, 2011. Widespread areas in eastern Japan were contaminated by the huge release of radioactive materials. We analyze the long-term effects of the accident on land prices by estimating the hedonic equation with regional fixed effects. Our estimation results show that the soil contamination by cesium-134/137 affected the surrounding land prices negatively; however, this effect disappeared after only one year. This implies that we should discreetly interpret the results in estimating the cost of the Fukushima nuclear accident by the hedonic approach.

The Fukushima Daiichi Nuclear Power Plant accident was caused by the Great East Japan Earthquake and the subsequent tsunami on March 11, 2011. Widespread areas in eastern Japan were contaminated by the huge release of radioactive materials into the environment. Immediately after the accident, the national government designated “evacuation order zones,” which included areas within a 20-kilometer radius of the nuclear plant, and “planned evacuation zones,” where the cumulative radiation dosage may have reached as much as 20 mSv after the accident. The number of evacuees due to the accident reached 164,865 people in the peak period of May 2012, and 89,319 people have been forced to evacuate over a long period as of July 2016 (Fukushima Prefecture, 2016). The Fukushima accident has had a significant impact on the Japanese economy.

According to Morishima, Sawa, and Takeuchi (2013), the Fukushima accident revealed the numerous risks of nuclear operations, including the costs involved with a nuclear accident. The accident has called into question the efficacy of energy policies in many countries. As of August 2016, most nuclear power plants in Japan have discontinued operations, and, correspondingly, the dependence on fossil fuels as an energy source has increased. The Japanese government has been forced to rethink its energy policy. Other countries have also followed similar paths; for example, Germany adopted a long-term plan to cease its operation of nuclear power plants. However, the United Kingdom decided to maintain its energy policy of reliance on nuclear power generation.

It is important to know how the Fukushima accident has caused indirect economic damage and to what extent such damage is permanent. Several previous studies
examined the economic losses caused by the Fukushima accident, most via the application of a hedonic approach (Yamane, Ohgaki, and Asano, 2013; Tanaka and Managi, 2015; Kawaguchi and Yukutake, 2017). Although these studies focused on the effects of the accident in the short term, the long-term effects have not been examined adequately because insufficient time has elapsed since the accident. In this study, we analyze the long-term effect of the Fukushima accident on land prices by estimating a longer term application of hedonic land price equations. We use real estate transaction data for the Fukushima prefecture from the first quarter of 2009 to the fourth quarter of 2012.

**Literature Review and Interpretation of Results from Hedonic Approach**

There are a lot of previous studies that estimate the effect of externalities on properties by the hedonic price approach [see Boyle and Kiel (2001) for a review]. Recently Wisinger (2014) examines whether a different approach to the information gathering process influences the relation between the level of chemical hazard and residential prices in these sites estimated by the hedonic technique. Allen, Austin, and Swaleheen (2015), using the spatial regression model, show that there are significant price differentials among houses adjacent to highways, those near high-traffic highways, and those farther from highway on-ramps. However few studies examine the effect of radioactive contamination on prices because of the rarity of such cases. Nelson (1981) and Gamble and Downing (1982) estimate the impact of the March 28, 1979 Three Mile Island Nuclear Generating Station accident on land prices in the surrounding areas. None of these studies finds a decrease in land prices in the surrounding areas after the accident. In particular, Nelson (1981) examines the longer term effects of the accident and confirms that the accident did not have an impact on land values in the long run.

Regarding the Fukushima accident, Yamane, Ohgaki, and Asano (2013), Tanaka and Managi (2015), and Kawaguchi and Yukutake (2017) systematically examine the property damage using a hedonic approach based on measured radioactive contamination. Yamane, Ohgaki, and Asano (2013) find that radioactive contamination caused a significant decrease in the land price evaluation by licensed real estate appraisers for property taxation. Tanaka and Managi (2015) examine the change in land prices due to the radioactive contamination from January 2011 to January 2012, and find a significant price decrease for radioactive contaminated land. Kawaguchi and Yukutake (2017), using real estate transaction data from the second quarter of 2010 to the first quarter of 2012, estimate the total land property damage to be approximately 0.13%–0.25% of Japan’s GDP. These studies using the hedonic approach supply very suggestive information on the cost of nuclear power generation.

It is important to internalize external diseconomies of nuclear plant risk, that is, to calculate people’s willingness to pay for radioactivity contamination applying the hedonic approach for the purpose of sustainable use of real estate close to nuclear plants. Recent studies concerning the effect of environmental quality on
property prices have paid particular attention to the endogeneity caused by the correlation between the observed environmental amenities and unobserved locational characteristics.

The hedonic approach requires the assumption that any factor that impacts property values can be held constant by introducing all such possible factors into the model. Therefore, we need the complete list of variables; however, there are no such studies that could control for all the factors. In order to address this problem, some studies employ the spatial regression model (Allen, Austin, and Swaleheen, 2015), while others introduce a fixed effect term into their model (Yamane, Ohgaki, and Asano, 2013; Kawaguchi and Yukutake, 2017). Seiler (2014), showing the weakness of the hedonic approach, applies the experimental design method to measure the externality of power lines on property values.

However, despite such careful treatment for endogeneity, hedonic analysis based on short-term information in these studies sometimes causes serious problems, particularly in situations when external diseconomies are changed. Such results should be carefully interpreted for two reasons. First, all of these studies confirm the negative value effect by a comparison of the property value at multiple time points, before and after the accident. Rosen’s (1974) hedonic model was considered at a time when preferences in the market were stable. Therefore, in extending the analysis at different points in time, we should impose an implicit assumption “stability over time” that is either identical preference over time or proper conditioning on changing preference (Parmeter and Pope, 2013). In such cases, we cannot directly interpret the result of the hedonic approach as the marginal willingness to pay (MWTP) for removing the contamination.

Second, the situation of the radioactive contamination keeps changing over time. The Japanese government published “the Decontamination Guideline” in December 2011, and “the Act on Special Measures (the Act on Special Measures concerning the handling of Environment Pollution by Radioactive Materials Discharged by the Nuclear Power Station Accident Associated with the Tohoku District-Off the Pacific Ocean Earthquake That Occurred on March 11, 2011)” came into force in January 2012. Through the Act, the Ministry of Environment designated “special decontamination areas” and “intensive contamination survey areas,” and decontamination was begun at the earnest. Exhibit 1 shows the progress of residential decontamination. The construction of one-half of 420,811 houses planned initially was completed in January 2015, and approximately 75% of affected residences were decontaminated by June 2016. Moreover, residents have easily been able to obtain information on the radioactive contamination over time. For example, over 3,000 monitoring posts and real-time dosimetry systems to measure spatial radiation dose were installed all over Fukushima prefecture in the year after the accident, and people were then able to know contamination information in detail. Wisinger (2014) examines whether the ways of obtaining information differentiate the impact of the externality on property prices and confirms that visual information has a strong influence on them. Therefore the installation of these systems probably does not have a small effect on the evaluation of the contamination.
Note: 420,811 houses are initially planned for decontamination (i.e., 100% = 420,811 houses). Source: the

Ganwande, Jenkins-Smith, and Yuan (2013) treat such long-term effects as an
event of negative externality. They confirmed the long-run effect of incidence-free
transport of nuclear waste by using Charleston County property sales data over
13 years. In this case, one event emerged, that is, the shipment of radioactive
spent nuclear fuel by train. So far, no accident has happened, the situation has not
changed, and the news of the shipment has also decreased. Namely there has been
no update of information on the shipment. In that sense, there is a high probability
that their analysis satisfies the assumption of stability over time.

In this study, we examine the time-varying effect of the Fukushima Daiichi
Nuclear Power Plant accident on land values by including the interaction terms
of quarterly time dummies and the contamination variable in the hedonic
approach. We merge the real estate transaction data with the degree of radioactive
contamination recorded one year after the accident, using a detailed geographic
unit (cho or oaza), which is as detailed as the U.S. ZIP Code, as the key. We
employ the geographic unit fixed effects model to allow for the correlation
between the unobserved land characteristics and proximity to the nuclear power
plant. Conditional on the location fixed effects, we argue that the degree of
radioactive contamination in each area is randomly determined by meteorological
conditions that lead to the movement of the radioactive-contaminated plume and
the timing of its radioactive release. Then we can interpret the coefficients of the
contamination as difference-in-differences estimators, as in Ganwande, Jenkins-
Smith, and Yuan (2013). Our estimation results show that the contamination
affected the land prices negatively. However, this effect did not last long and
disappeared after one year. That is, the effects have changed over time. We analyze
our sample for the period between the first quarter of 2009 and the fourth quarter
of 2012. As shown in Exhibit 1, this did not cover the period after the beginning

\[\text{Exhibit 1 | Progress of Residential Decontamination}\]
of the full-scale decontamination plan. Therefore, our results do not show the
effect of the actual decontamination on the land price but the effect of prospective
decontamination and changes in the recognition of the contamination. This implies
that we should discreetly interpret the results in estimating the cost of the
Fukushima Daiichi Nuclear Power Plant accident using the hedonic approach.

Data and Methods

Data

We use two sets of data to construct our sample for the estimation of the hedonic
property price equation. The first set deals with real estate transactions before and
after the Fukushima accident by geographic location. The second set measures the
degree of radioactive contamination after the accident by geographic location.

The data source for the first set is the Land General Information System
maintained by the Ministry of Land, Infrastructure, Transportation and Tourism
in Japan. The ministry sends a survey to all the new owners of real estate registered
with the regional Legal Affairs Bureau. The timing of transactions is recorded on
a quarterly basis. Because a unique identification number for each property has
not been disclosed, we cannot construct property-level panel data and analyze by
the repeat sales method. Thus, we obtained the micro data of each transaction
from the Ministry’s website. We use this sample for observations from the
Fukushima prefecture between the first quarter of 2009 and the fourth quarter of
2012.

The survey includes information on the attributes of each transacted real estate,
for instance, the location, price, area, and shape of the land, the width of the
facing road, regulations on land use, and the name of and distance to the nearest
railway station or bus stop. We use the price per square meter of land as the
dependent variable and the attributes of the land as the independent variables.

The second data source is the airborne survey conducted by the Ministry of
Education, Culture, Sports, Science and Technology (MEXT) in Japan. Exhibit 2
shows the monitoring results that show the degree of soil contamination by
cesium-134 and cesium-137 per square meter (unit: kBq), as of August 28, 2011
[see Yoshida and Kanda (2012) for a brief explanation]. We can obtain continuous
data, which consists of radioactive cesium deposition densities at the median
points of the quarter grid squares (approximately 250 m x 250 m) defined by JIS
X 0410. We use the data as of May 31, 2012. We match the grid data and the
transaction data using geographic information system (GIS) software and identify
the most prevalent degree of contamination within detailed geographic units (cho
and oaza) in terms of land area. These geographic units are a subdivision of local
municipalities. The distribution of radioactivity is determined by not only the
distance from the nuclear plant, but also the meteorological conditions just after
the explosion of the reactor covers. A series of explosions affected different
regions depending on the movement of plumes and precipitation.
Two meteorological events were particularly important in determining soil contamination: the precipitation on March 15 in the northwest and western areas of the plant, which intensely contaminated the areas; and the precipitation on March 21 that contaminated the area 200 km south of the plant (Mathieu et al., 2012; Yoshida and Takahashi, 2012). Although the distribution of the radioactive contamination used in this study is the one published in May 2012, the media started reporting a similar map as early as a month after the accident, in April 2011. (The distribution of the radioactive contamination shown in Exhibit 2 is the one published in August 2011.) The U.S. National Nuclear Security Administration, for example, published monitoring results around Fukushima Daiichi on April 3, 2011 that are similar to those published by the Japanese government in November 2011.

Other than such maps, people can obtain information daily on the spatial radiation dose rate of principal cities and towns from newspapers and TV programs. Especially, in Fukushima prefecture, over 3,000 monitoring posts and real-time dosimetry systems to measure spatial radiation dose have been installed on
schools, kindergartens, hospitals, and other public spaces since February 2012, in addition to conventional monitoring posts. The monitoring data are available from the monitoring posts, as well as via a website of Fukushima prefecture (http://fukushima-radioactivity.jp/pc/) in real time since April 2012. Furthermore, local governments in Fukushima prefecture distributed integrating dosimeters to 280,000 people (children up to junior high school and pregnant women) in the summer of 2011. People can even buy a simple dosimeter via the Internet for around USD 100. In such situations, people can easily obtain information on the radioactivity in real time. We therefore assume that consumers started reacting to information about the contamination immediately after the accident.

We match the transaction data with the radioactive fallout data using geographic units (cho and oaza) as the key variables. The data include 7,529 land transactions from 1,274 geographic units. Exhibit 3 reports the descriptive statistics of the sample.

In the heavier contaminated areas, there is a possibility that radioactive contamination affects not only the land value but also the amount of land transactions. Exhibit 4 shows the number of transactions by the degree of radioactive contamination every three months. The total number of transactions decreased sharply in all categories at the time of the accident in 2011:Q1; however, it recovered immediately after the accident. Especially, a sharp increase is observed after 2012:Q2. This trend is probably due to the reconstruction demand. However, the recovery trend is weak in the heavier contaminated areas. The more contaminated the land was after the accident, the fewer transactions that took place on it.

We next examine the change in prices of transacted land. Exhibit 5 displays the land price per square meter by the degree of radioactive contamination. An increase in radioactive contamination is generally associated with a decrease in land price. The aggregate average land price shows that the land price decreased sharply just after the accident and has not recovered to the level in the pre-accident period. The less contaminated areas show virtually no change between the pre- and post-accident periods with the exception of 2011:Q3. In the heavier-contaminated areas, land prices decreased sharply compared with the aggregate price, but recovered quickly. Prices reached the pre-accident level in 2012:Q1.

These exhibits show that the degree of radioactive contamination is negatively associated with both the number of transactions and land prices. These findings suggest that radioactive contamination of land depreciates the value of residential land. The rough tabulation, however, prevents us from identifying the causal impact of radioactive contamination on the value of residential land and its effect over time, as we do not control for the change in land attributes between the pre- and post-accident periods.

**Hedonic Approach**

We model the natural logarithm of land price per square meter as determined by the following hedonic price equation:
### Exhibit 3 | Descriptive Statistics

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<td>Size of land: m²</td>
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<td>1,602.23</td>
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<td>Width of facing road: m</td>
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<td>4.17</td>
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<td><strong>Types of Land Shape</strong></td>
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<td></td>
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<td>Almost square or rectangular</td>
<td>0.08</td>
<td>0.28</td>
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<tr>
<td>Almost square</td>
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<td>Almost rectangular</td>
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<td>Trapezoid</td>
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<td>Rectangular</td>
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<td>Other purpose area</td>
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</tr>
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<td>Q3_2009</td>
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</tr>
<tr>
<td>Q4_2009</td>
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<td>Q2_2010</td>
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<td>Q3_2011</td>
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<td>0.211</td>
<td>0</td>
<td>1</td>
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<tr>
<td>Q4_2011</td>
<td>0.064</td>
<td>0.245</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Q1_2012</td>
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<td>Q2_2012</td>
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<td>Q3_2012</td>
<td>0.089</td>
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<td>Q4_2012</td>
<td>0.105</td>
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</table>

*Note: For residential land, N = 7,529.*
**Exhibit 4** | Change in the Numbers of Transactions by the Degree of Contamination
(2009:Q1 = 0.0%)

**Exhibit 5** | Change in the Land Transaction Prices / m² by the Degree of Contamination
(2009:Q1 = 0.0%)
where \( i \) is the index for a transaction; \( j \) is the index for the regional unit (cho or oaza); \( t \) is the index for the quarter; \( P_{ijt} \) is the transacted price of land per square meter; \( D_t \) is the year quarter dummy variable for post-accident transactions; \( C_{sj} \) is the radioactive contamination level in the post-accident period; \( \text{distance}_j \) is the distance from the Fukushima Daiichi Nuclear Power Plant; \( X_{it} \) is the vector of dummy variables for land attributes, including the shape of land, the regulation on land use, size of land, width of facing road, and distance from the nearest station to the property; \( a_j \) is the time-invariant unobserved characteristics of region \( j \) (1,274 geographic units); and \( u_{ijt} \) is the idiosyncratic disturbance.

In the hedonic model, we assume a log-log relation between the two dependent variables—the degree of contamination and the distance from the Fukushima Daiichi Nuclear Power Plant—and the price of land. Using the price logarithm as a dependent variable is desirable because a change in the explanatory variable has a proportional effect on the pre-accident price, and it is indeed widely used in the literature (Boyle and Kiel, 2001). Our sample includes areas that were almost unaffected by contamination even after the accident. The level of contamination is observed as zero in such areas, which is the same level as before the accident. Since the zero observations cannot be converted to logarithmic form, we replaced them as a median of 5,000 bq between 0 and 10,000 bq, which is a minimum detectable value, and then transformed them to logarithmic form. In fact, a small amount of cesium contamination existed even before the Fukushima accident due to atmospheric nuclear tests in the 1960s. This operation does not cause any problems in the results.

The key identifying assumption of our estimation is the non-correlation of \( \ln C_{sj} \) and \( u_{ijt} \), conditional on other covariates and regional fixed effects. The geographic spread of the radioactive fallout after a power plant failure is almost entirely dependent on the timing of the explosion of the structures that cover the nuclear reactors and the meteorological conditions around the time of the event, as suggested by several simulation studies (Mathieu et al., 2012; Yoshida and Takahashi, 2012). The movement of the radioactive plume and precipitation after the accident were major determinants of the geographic distribution of radioactive contamination, although these meteorological conditions hardly affected the residential land value through pathways other than radioactive contamination of the land. Therefore, we believe that the post-accident degrees of contamination and the time-variant regional shocks are not systematically correlated.

Similarly, we assume that there is no correlation between \( \ln \text{distance}_j \) and \( u_{ijt} \) because the equation is conditioned on the regional fixed effects. The correlation
between the distance from the nuclear plant and the time-invariant region-specific price component apparently is negative. The densely contaminated area close to the power plant was priced lower even in the pre-accident period. Poor rural local municipalities accepted the nuclear power plant with the hope of local job creation and an increase in tax revenue (Ando, 2015). The negative correlation by the endogenous location can be eliminated by estimating the model with fixed effects estimation.

Under these assumptions, the coefficients of $D_{t} \ln Cs_j$ and $D_{t} \ln distance_j$ in Equation (1) can be interpreted as DID estimates, as with the analysis in Gawande, Jenkins-Smith, and Yuan (2013). Our data includes observations after the accident in 15 municipalities that were not designated as “special decontamination areas” or “intensive contamination survey areas.” Since such observations exist in the areas that satisfy the radiation regulation before the accident (under 1 mSV per year), they can be interpreted as the control group and are about 11% of the observations after the accident.

**Estimation Results**

**Estimation Results for the Hedonic Function**

Column (1) of Exhibit 6 reports the hedonic regression results of residential land price on the logarithm of distance from the Fukushima Daiichi Nuclear Power Plant and the other characteristics of land. In this model, the variable of distance contains no information on the proximity to the plant itself, but has information on the degree of contamination as a proxy variable, because we control regional fixed effects excluding the case when the effect of proximity changes over time. The coefficients for the interaction term of the logarithm of distance from the nuclear plant and the quarter time dummy variable between the first and fourth quarter of 2011 are estimated to be positive but statistically insignificant. These results indicate that the distance from the plant does not serve as the proxy variable for the contamination, as anticipated. After the first quarter of 2012, the coefficients are estimated to be negative and even significant for $Q3_{2012}$ and $Q4_{2012}$. The estimated coefficient, $-0.343$, implies that a 1% increase in the distance decreases the residential land price by 0.343%. Namely, the closer the land to the nuclear plant, the higher the evaluation of the land.

The coefficients for the other independent variables are quite standard. The coefficient of scale of the site area has a positive and significant effect on the land price. The land near a station or facing a wide road has a high evaluation. An irregular shape of the land decreases its price. While being designated as a commercial area increases the price, the land, which is designated as a manufacturing area or others, has a lower price.

Column (2) of Exhibit 6 shows the hedonic regression results that replaced the logarithm of distance with the logarithm radioactive fallout. The coefficients for the interaction term of the logarithm of contamination and the quarter time dummy variable are estimated to be significant between the second quarter of 2011 and
### Exhibit 6 | Estimation Results for the Hedonic Function (Q1_2009–Q4_2012)

<table>
<thead>
<tr>
<th>Variables</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>Variables</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
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<tr>
<td>Time dummy × log distance (Base category: Before accident)</td>
<td></td>
<td></td>
<td></td>
<td>Time dummy × log Cesium 134/137 (Base category: Before accident)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q1_2011</td>
<td>0.094</td>
<td>0.058</td>
<td>(0.247)</td>
<td>0.094</td>
<td>(0.071)</td>
<td>(0.072)</td>
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<tr>
<td></td>
<td>(0.172)</td>
<td>(0.253)</td>
<td></td>
<td></td>
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<tr>
<td>Q2_2011</td>
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<td>0.079</td>
<td>(0.148)</td>
<td>0.169</td>
<td>(0.061)</td>
<td>(0.064)</td>
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<td>-0.041</td>
<td>(0.148)</td>
<td>0.053</td>
<td>(0.072)</td>
<td>(0.075)</td>
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<tr>
<td></td>
<td>(0.149)</td>
<td>(0.194)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
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<td>(0.403)</td>
<td>0.332</td>
<td>(0.060)</td>
<td>(0.065)</td>
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<td></td>
<td>(0.405)</td>
<td>(0.194)</td>
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<tr>
<td>Q1_2012</td>
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<td>-0.201</td>
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<td>-0.149</td>
<td>(0.051)</td>
<td>(0.052)</td>
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<tr>
<td></td>
<td>(0.149)</td>
<td>(0.149)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Q2_2012</td>
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<td>-0.171</td>
<td>(0.034)</td>
<td>(0.037)</td>
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<tr>
<td></td>
<td>(0.139)</td>
<td>(0.139)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Q3_2012</td>
<td>-0.343**</td>
<td>-0.383***</td>
<td>(0.134)</td>
<td>-0.343**</td>
<td>(0.042)</td>
<td>(0.041)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.133)</td>
<td>(0.042)</td>
<td></td>
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</tr>
<tr>
<td>Q4_2012</td>
<td>-0.267**</td>
<td>-0.295***</td>
<td>(0.116)</td>
<td>-0.267**</td>
<td>(0.043)</td>
<td>(0.039)</td>
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<tr>
<td></td>
<td>(0.114)</td>
<td>(0.043)</td>
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</tr>
</tbody>
</table>

*Significant at the 10% level
**Significant at the 5% level
***Significant at the 1% level
### Exhibit 6 | (continued)

Estimation Results for the Hedonic Function (Q1_2009–Q4_2012)

<table>
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<th>Variables</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>Variables</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
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<td>Land use regulation (Base category: Residential area)</td>
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<tr>
<td>Log size of land</td>
<td>−0.177***</td>
<td>−0.175***</td>
<td>−0.176***</td>
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<td>0.105*</td>
<td>0.108*</td>
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<td>0.089***</td>
<td>0.090***</td>
<td>Manufacturing area</td>
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<td>(0.071)</td>
<td>(0.071)</td>
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<td>Log distance to station</td>
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<td>−0.176***</td>
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<tr>
<td>Almost square or rectangular</td>
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<td>0.157***</td>
<td>0.158***</td>
<td>Constant term</td>
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<td>0.336***</td>
<td>0.340***</td>
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<td>Yes</td>
<td>Yes</td>
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<td>Square</td>
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<td>(0.059)</td>
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<td>(0.102)</td>
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</tr>
<tr>
<td>Trapezoid</td>
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<td>0.201***</td>
<td>0.201***</td>
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<td>(0.050)</td>
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<td>Rectangular</td>
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<td>0.273***</td>
<td>0.273***</td>
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<td>(0.039)</td>
<td>(0.039)</td>
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</table>

Notes: The sample size is 7,529. Standard errors robust against the regional unit-level clustering are reported in parentheses.  
* p < 0.1  
** p < 0.05  
*** p < 0.01.
**Exhibit 7 | The Result of Placebo Test (Q1_2009–Q4_2010)**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coeff.</th>
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<td>Second term dummy × log distance from nuclear plant</td>
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<td>(0.074)</td>
</tr>
<tr>
<td>Second term dummy × log Cesium 134/137</td>
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<td>(0.036)</td>
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<td>Variables of other land characteristics</td>
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<td>District F.E.</td>
<td>Yes</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.020</td>
</tr>
</tbody>
</table>

Notes: The sample size is 3,490. Standard errors robust against the regional unit-level clustering are reported in parentheses.

* $p < 0.1$
** $p < 0.05$
*** $p < 0.01$.

the first quarter of 2012. However, these effects tend to decrease over time and we cannot confirm the statistical significance after Q2_2012. These results imply that the negative evaluation for the contamination disappeared only one year after the accident.

Column (3) of Exhibit 6 reports the results of the hedonic model that includes two types of interaction terms: (1) the terms of the distance and the time dummy variables; and (2) the terms of the contamination and the time dummy variables. All estimated coefficients are almost the same as those shown in columns (1) and (2). These results show that the distance and the contamination do not depend on each other in this specification and have different impacts on land prices. In the second quarter of 2011, a 1% increase in the contamination decreases land prices by 0.127%. However, such effects did not last long. In the first quarter of 2012, the effect decreased to 0.099% and lost statistical significance after the second quarter of 2012.  

**Estimation Results for Placebo Regression**

In this subsection, we confirm that the radioactive fallout does not affect land prices before the nuclear disaster. To implement such a placebo test, we divide the sample into two parts only using the pre-accident period (the first term: the first quarter of 2009 to the fourth quarter of 2009; the second term: the first quarter of 2010 to the fourth quarter of 2010) and examine whether the systematic difference of the price trend exists between the two groups using the same hedonic function as in the previous section. Then, the model includes two interaction terms: (1) the logarithm of the distance from the nuclear plant and the second-term dummy variable; and (2) the logarithm of contamination and the second-term dummy variable.
Exhibit 7 presents the results of the placebo test. The coefficients of both the interaction terms are insignificant. Therefore, the effect of radioactive contamination on the land is only observed after the accident and does not include other information in the pre-accident period.

**Conclusion**

In this study, we examined the time-varying effect of the Fukushima Daiichi Nuclear Power Plant accident on land values. We used hedonic price equations with detailed regional unit fixed effects and obtained the following results. First, the contamination had a negative effect on land prices. However, the effect did not last long and disappeared after only one year. Second, the distance from the nuclear plant did not have an impact on the land prices immediately after the accident. That is, the effect of distance did not decay as the distance became larger. On the contrary, after the first quarter of 2012, the coefficients are estimated to be negative and even significant for the third and fourth quarters of 2012. These results imply that properties in the neighborhoods surrounding the Fukushima Daiichi Nuclear Power Plant have higher land values. The proximity to the nuclear plant does not serve as a proxy variable of the contamination.

Furthermore, the distance and contamination variables have an independent relation in our model, since the existence of the distance variables does not affect the estimates of the contamination coefficients and vice versa. These results indicate that the degree of radioactive contamination in each area is determined not by distance from the plant but by random meteorological conditions since
there are no land transactions due to residence restriction in more severely contaminated areas that are quite close to the plant and the influence of distance on the contamination relatively decreased.

It is noteworthy that the disappearance of the contamination effect at the end of 2011 and the beginning of 2012 coincided with the appearance of the distance effect in our results. These results contradict the analysis of Gawande, Jenkins-Smith, and Yuan (2012), which confirmed the lasting impact of nuclear waste shipment on property prices. The contradiction reflects a difference in the frequencies of information updating.

There was one event at the start of spent nuclear fuel shipment by train in the case of Gawande, Jenkins-Smith, and Yuan (2012), while the information continues to be updated in our analysis. For example, the government published “the Decontamination Guideline” and enforced “the Act on Special Measures” at the beginning of 2012. Through the Act, the Ministry of Environment designated “special decontamination areas” and “intensive contamination survey areas.” It began decontamination planning in more detail. Furthermore, over 3,000 monitoring posts and real-time dosimetry systems to measure the spatial radiation dosage over Fukushima prefecture are installed at almost the same time. As people obtain more accurate information on the radioactive contamination, they have been able to judge the actual influence of the radiation pollution on their health. For example, they understand what the maximum acceptable dosage level means and know how to properly deal with the contamination. Therefore, the estimation results indicate that although uncertainty still remains in the market to some extent, the prices of land have recovered from those in the panic transactions held immediately after the nuclear accident. There is a possibility that some people, especially evacuees, understood the risk even from a small amount of contamination and determined to switch from temporary evacuation to migration.

The new housing demand by evacuees from the evacuation order areas and by the reconstruction workers may be reflected in this effect. Exhibit 8 shows the transition of residential land in each region in Fukushima prefecture. The transactions of residential lands in the coastal area, where the Fukushima Daiichi Nuclear Power Plant is located, rapidly increased after the second quarter of 2012.

Our analysis is highly suggestive in estimating the cost or loss due to a nuclear power plant accident. In the traditional hedonic approach, cost due to an external diseconomy is estimated based on the MWTP in a buyer’s bid. In order to apply this method, however, the model should be based on an important assumption, namely “stability over time,” which indicates the consumer’s preference is stable at different points in time (Parmeter and Pope, 2013). The assumption is not satisfied by the time-varying effect and the cost has a severe bias. Therefore, we should discreetly interpret the cost and the MWTP by the hedonic model using a sample over multiple time periods the same as this study.9

Future research should consider sample selection bias in order to obtain a more accurate analysis. Exhibit 4 shows that the degree of radioactive contamination is
negatively associated with the number of transactions. The contamination decreases the value of land to a point where no further transactions occur. This decrease in the volume of transactions may result in an underestimation of the land damage because the areas severely damaged were not transacted after the accident and do not appear in our sample. However, our study does show the effects over time and the dissipation of negative impacts over time of property no longer contaminated.

**Endnotes**

1. Millisievert is abbreviated as mSv. Sievert is the index the airborne survey of radiation effect for organisms (include humans).
2. Eleven municipalities in Fukushima prefecture were designated as special decontamination areas where the annual cumulative dose of radiation could be more than 20 mSv/y. The decontamination of these areas is being implemented by the national government.
3. The intensive contamination survey areas include 104 municipalities in 8 prefectures, where the additional exposure dose was over 1 mSv/y. Decontamination is implemented by each municipality with financial and technical support from the national government.
4. Kilobecquerel is abbreviated as kBq. Becquerel is a measurement unit of radioactivity, equal to one radioactive decay per second.
5. The areas adjacent to the Fukushima Daiichi Nuclear Power Plant are excluded from the airborne survey since the contamination of land cannot be distinguished from the direct effect of radioactive material at the plant. However, no lands have been traded in the areas.
6. For example, the postal address of The Tokyo Metropolitan Government Office is “2-8-1 Nishi-Shinjuku, Shinjuku-ku, Tokyo.” In this address, “Nishi-Shinjuku” is the cho or oaza.
8. We also estimate the same model for longer periods from the first quarter of 2009 to the first quarter of 2015. The results are almost the same and we can confirm the existence of the time-varying effects.
9. Refer to Parmeter and Pope (2013) for further details about interpreting estimates using the hedonic approach in program evaluations, especially including samples at multiple points of time.

**References**


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Non-spatial Contagion in Real Estate Markets: The Case of Brookland Greens

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Abstract
We investigate contagion in real estate markets by evaluating the effects of a widely publicized landfill contamination event in one local market on the price of homes near landfills in non-impacted markets within the same metropolitan region. The impact of proximity to open, closed, and redeveloped landfills in the directly affected and contagion neighborhoods is tested at distances varying from \(<500\) meters to \(2,500\) meters using the traditional hedonic pricing model. The results are mixed and relative to the current use of the landfill as closed, capped, and redeveloped landfills show no impact. Sites that are capped yet undeveloped and sites with open fills appear to show some impact, although further research is needed to support any contagion effects.

There is a substantial amount of research quantifying the relation between proximity to environmental (dis)amenities and value. Amenities such as golf courses (Do and Grudnitski, 1995; Shultz and Schmitz, 2009), scenic views (Benson, Hansen, Schwartz, and Smersh, 1998; Hindsley, Hamilton, and Morgan, 2013), and green space (Bolitzer and Netusil, 2000; Cho, Bowker, and Park, 2006) positively affect value while negative effects are shown in proximity to landfills (Reichert, Small, and Mohanty, 1992; Hite, Chern, Hitzhusen, and Randall, 2001), high traffic noise (Nelson, 2008), and environmental contamination (Simons and Saginor, 2006) such as oil spills. These relations are based on a two-tier spatial component, as well as the principle of substitution (i.e., the value of one property is directly related to the value of adjacent or similar properties, all else held equal). The first spatial component is a direct effect wherein a property is immediately adjacent to or directly affected by the (dis)amenity. The other spatial component links the value of unaffected properties to the change in value of nearby affected properties. Therefore, when a property abuts another that is directly affected by an environmental (dis)amenity, its value is impacted, although likely not to the same degree as the directly impacted property.

In this paper, we provide further evidence of these phenomena by investigating the case of a housing estate, Brookland Greens Estate, and an adjacent landfill located near Melbourne, Australia. We test the spatial relations between properties directly and indirectly affected by the issues associated with the landfill. What we seek to address is not the spatial relation between properties per se, but rather how and to what extent the diminution in property values spreads to non-spatially
related, similar markets. The framework for this is based in contagion theory where an event in one market spills over to another that has little or no direct spatial relation to the first.

We hypothesize that a detrimental event associated with a particular type of land use (landfill in this case) and evidenced in a diminution in the value of nearby properties may have a “contagion effect” in which real estate proximate to other land uses of this type, although not proximate to the initial event, will experience similar phenomena, even though they are not directly affected by the detrimental event (i.e., non-spatial market contagion). The key mechanism tested is the ability of a distant (spatially) event to raise awareness of the potential negative externalities of an existing disamenity and how this contagion may affect observed market outcomes. While the results are inconclusive, they do suggest a mild contagion effect in some of the submarkets, particularly where the landfill has not been redeveloped.

We next discuss the literature on contagion theory, as well as the spatial and non-spatial effect of social (dis)amenities on observed market behavior. A description and analysis of the landfill case and its associated regulatory environment follows. After explaining the methodology and data, the main findings are presented on the direct price impact and possible contagion effects on capped and redeveloped landfills. We conclude with further interpretation and a discussion on future research.

**Literature**

This research is framed in contagion theory—unexposed markets are subject to impacts similar to an affected market by virtue of that similarity—leading us to make a few assumptions about the cause of those effects. First, we assume information transparency and transmission in residential markets (e.g., time lag and market reaction) is measured by price change. We also assume there are at least two types of “spatial reactions”: (1) impact at the landfill area, the continuous spatial contagion effect; and (2) landfill areas in other regions, the non-spatial (discrete) contagion effect. A third reaction, not addressed in this research, is (3) a contagion effect on contaminated sites other than landfills, reflecting human ability to relate events (e.g., by imagination). If information transmission efficiency is the dominant force, there will be the negative price relation of (1) > (2) > (3), or else other market or non-market forces or behavioral theories may exist to explain the contagion effect.

We also assume that there is likely a diminution in value associated with the stigma of living near a landfill that is already capitalized into the market value of the properties. Stigma refers to the real or perceived, readily identifiable issues associated with landfills or other contamination sources that may affect property value. Consequently, it is important to understand the level at which a community is aware of the disamenity and its implication for occupants and future home purchasers. We posit that when a contagion event occurs, stigma effects, whether
present or not, will be magnified or will emerge relative to proximity alone, thus we do not control for directional heterogeneity as suggested in Cameron (2006).

The literature review that follows is rooted in these assumptions. We begin with an overview of contagion theory, followed by studies that investigate the links between stigma, location, and house prices from spatial, non-spatial, and social justice perspectives.

Contagion Theory

According to contagion theory, groups of people, by virtue of communication with the social networks they engage in, are likely to adopt the attitudes and behavioral norms of the group. Just as a virus spreads through personal contact, so do attitudes, behaviors, and actions. Efforts to influence do not have to be present; the mere existence of communication portals is enough. These links are well established in the literature beginning with the Ryan and Gross (1943) study of hybrid seed corn and continuing through today with a vast number of studies conducted in the financial markets (e.g., Ghosh, Guttery, and Sirmans, 1998; Mink and de Haan, 2013; Caccioli, Shrestha, Moore, and Farmer, 2014; Chen, Tsai, Sing, and Yang, 2015). Contagion may be transmitted through social or public (e.g., media) channels.

Contagion studies in the real estate and other financial literature typically follow a predictable pattern and often focus on negative economic or other shocks and the resulting behaviors, actions or attitudes of individuals, organizations or communities. When an event occurs, information flows through communication networks, elevating levels of perceived risk. As perceived risks increase and information flows from person to person, the “group belief” reinforces or intensifies. The group may then engage in illogical, emotionally-driven activities they would not necessarily engage in as individuals, primarily due to the anonymity the group provides. The fluidity of communications within existing social networks helps create and refine new behaviors, attitudes, and actions that become socially acceptable, if only for limited time.

The rapid pace at which movements, ideas, and/or activities can spread has the potential to impact markets on a global scale, particularly given recent technological improvements in communication. Research by Seiler, Collins, and Fefferman (2013) shows that the number of strategic mortgage defaults during the Global Financial Crisis (GFC) were likely exacerbated by the suggestion that underwater homeowners exercise their put option, further depressing home values and predating the market collapse. Prior to the GFC, most defaults were economic, the result of job loss or divorce, for example. Strategic defaults, conversely, were based on the mortgagor’s willingness to “turn over the keys” to the lending institution because the value of the mortgage was greater than that of the collateral. Strategic defaults were comparatively rare before that time.

Freybote and Fruit’s (2015) study of media coverage in the case of the construction of a natural gas pipeline provides additional evidence of how information networks
contribute to market contagion. The authors investigate how residential properties are impacted by proximity to the pipeline and how unrelated pipeline explosions in different markets affect value during the subject pipeline construction process. Consistent with prior literature, they find that proximity to the pipeline negatively affected value. Further, they also determined that the perceived riskiness of proximity to natural gas pipelines increases in months when a fatality associated with an explosion is widely reported in the media, and prices near the pipeline under construction moderate.

**Stigma, Location, and House Prices**

The literature on the effects of environmental disamenities on value is lengthy and well established with studies focused on landfills (Nelson, Genereux, and Genereux, 1992; Gunterman, 1995; Hite, Chern, Hitzhusen, and Randall, 2001), Superfund sites (Michaels and Smith, 1990; Kohlhase, 1991; Kiel, 1995; Kiel and McClain, 1995; Kiel and Zabel, 2001), and leaking underground storage tanks (Sementelli and Simons, 1997; Simons, Bowen, and Sementelli, 1999; Simons, Levin, and Sementelli, 2009), for example. In general, these studies show a significant negative effect associated with proximity that decreases as distance from the source of the contamination increases. Studies showing little to no effect are typically site specific or address less intense uses, as shown in Ready’s (2010) research on low-volume landfills. Others show the effects are unequally distributed based on direction (Cameron, 2006) or property type (Ihlanfeldt and Taylor, 2004).

Empirical inquiry into the relation between environmental hazard, stigma (e.g., landfill), and land prices fall under (1) a spatial perspective or (2) a non-spatial perspective. The former links to mainstream location (urban economic) theory, while the latter links more closely to information economics and behavioral ideas. A third stream of analysis concerns normative strategy and decisions such as location choice, social justice and compensation determination, data, methodology, and the cross-context applicability of results.

**Spatial Perspective**

Brasington and Hite (2005) estimate spatial effects using the demand price elasticity of homes in relation to the source of pollution. They find that “point-source pollutants” and nearby house prices are negatively correlated, while income, education, and concern for children are sensitive to the location of polluted site. Eshet, Baron, Shechter, and Ayalon (2007) estimate the economic value of disamenities by measuring the spatial impact of waste transfer stations on local property prices. In addition to the expected negative relation, they also raise issues on the measurement of externalities and the hedonic pricing model. Hanna (2007) focused on the dynamic relation of a polluting industrial site, house price, and household mobility as determined by income, finding that income and pollution are strongly correlated. Cameron (2006) argues the existence and significance of directional heterogeneity and its role in determining the actual spatial price effect of environmental hazard.
Non-spatial Perspective

McCluskey and Rausser (2003a) suggest the possibility of short-term and long-term stigma due to discovery and clean-up associated with the hazardous site, emphasizing the relation between household income, discounted property values, and social segregation. Messer et al. (2006) discuss the significance of stigmatization in the case of clean-up action on environmentally damaged sites, specifically focusing on the impact of people’s memory in forming persistence perceptions over a long period of time. Messer’s study exposes an interesting hypothesis: If cleanup is treated as an investment to counter-act existing social cost (e.g., land pollution) and the build-up of negative perception (e.g., stigma), the actual level of damage and price behavior is likely dependent on the supply elasticity of suitable replacement sites. Reichert (1997) finds that polluted landfills tend to have liquidity, distance, and permanent devaluing effects on associated property markets. McCluskey and Rausser (2003b) suggest that clean-up actions on hazardous sites may not be as effective as new information about an environmental issue in triggering change in behavior and expectation in consumer valuation. Their findings support earlier research by Kiel and McClain (1995).

Social Justice and Distribution Perspective

Palmquist and Smith (2001) evaluate the use and effectiveness of the hedonic technique to evaluate environmental policy and litigation. They suggest market price based models are less directly relevant to public policy but have direct relevance to litigation that is empirical and fact-based. Simons and Winson-Geideman (2005) applied the contingent valuation method to understand buyer perceptions of hazardous sites on residential property. Caplan, Grijalva, and Jackson-Smith (2007) investigate the extent that a non-host community compensates a host community for the actual and perceived impacts of a landfill. They test and argue the value of using the resource-resource format for landfill site evaluation and decision-making, because it allows the parties to be aware of and compare alternative resource trade-offs and suitable forms of compensation for a host community.

In the Australian context, Bond (2001) and Chan (2001, 2002) investigate the role of stigma and associated risk perceptions in the valuation of contaminated land in Australia’s capital cities. They identify risk factors and decision models to approach landfill site evaluation. Wu and Chen (2012) use a structural-agent approach to investigate the legal framework and process that Melbourne has implemented for its inner city brownfield sites, leaving specific investigation of the relation between environmental hazard and house price (e.g., from spatial or non-spatial perspective) unattended. In this study, we fill this gap by paying special attention to the contagion effect within a specific legal policy framework in Melbourne, Australia, a major city that is frequently regarded as having high-quality living standards and property environments.
The Brookland Greens Case and Corresponding Regulatory Environment

The Brookland Greens case began in 1992 when the Shire of Cranbourne (eventually becoming the City of Casey in 1994) approved the development of a landfill located on Stevenson’s Road, about 30 kilometers from the Melbourne CBD. The area was generally rural and undeveloped and the landfill approved as a Type II by the Environmental Protection Agency (EPA) to accept putrescible waste, which is biodegradable and produces landfill (methane) gas (see Exhibit A1 in the Appendix for details regarding landfill types).

Under the terms of the Environmental Protection Act of 1970, state governments are vested with the right to govern the construction and operation of landfills, and it is the EPA’s responsibility to monitor and regulate them. The EPA grants permits for new sites, examines them for compliance, and then issues a license to operate when the work is complete. The license includes conditions for operation, limits on discharge, maintenance, reporting, and monitoring with the objective of minimizing any negative impact on the environment (Brouwer, 2009). Councils (local government) generally have the responsibility of issuing management contracts, thus they also hold a level of responsibility for the operation of the landfills.

Records show that, in order to contain the methane gas at the Stevenson’s Road site, the EPA intended for the landfill to be lined with compacted clay, but through a series of missed deadlines and poor negotiations, the liner was not installed. Construction was completed and a license to operate was granted regardless. Operations began on the site in June 1996 (Brouwer, 2009).

In 1999, Peet & Co., a residential development company, began construction of a housing development known as Brookland Greens Estate on land adjacent to the landfill. In early 2000, the developer petitioned the city to have parts of the site rezoned to Residential Zone 1 to facilitate the construction of additional housing units. At the same time, the developer was engaged in discussions with the EPA regarding the appropriate buffer distance required to minimize the impacts of the fill to nearby home owners. After a number of panel hearings debating 200-meter and 500-meter distances, the EPA panel sided with the developer and supported the 200-meter buffer for Brookland Greens. Incidentally, in 2001, the EPA published the Best Practices Environmental Management, Siting, Design, Operation and Rehabilitation of Landfills, recommending a 500-meter distance for all other fills.

The City of Casey complied with the 200-meter request, noting that no homes were to be built within that distance. Not to be deterred, the developer approached the Victorian Civil and Administrative Tribunal (VCAT) for permission to construct stage 10 on land that was partially located within the 200-meter landfill buffer. The proposal was approved by VCAT in May 2004, who ruled that the 200-meter buffer distance was to be measured from the “active tipping area,”
being the “active tipping face” of the landfill. This ruling effectively allowed the developer to build up to the perimeter of the fill (Brouwer, 2009). However, when the required disclosures were made for the subsequent sale of Brookland Greens homes, the site was referred to as “sand extraction operations” and not as a landfill.4

In June 2005, the landfill ceased operations and less than a year later the EPA received an anonymous complaint about “bubbling storm water puddles” on the Brookland Greens Estate development site. Initial tests found that methane gas and carbon dioxide had entered the aquifer and was migrating from the landfill into the estate. A post-closure pollution abatement notice was issued, taking effect on February 2, 2007, and the waste discharge license was revoked later that month (Brouwer, 2009).

Testing began at houses within the estate, and on August 31, 2008, methane gas at 63% volume for volume of air was found in one of the homes. On September 9 the residents were declared to be in imminent danger and the County Fire Authority was made responsible for leading the emergency response. Twenty-nine families were instructed to evacuate their homes immediately for fear they would explode. As word spread and the media began reporting the story, the EPA refused to release any information on which of the 35 other landfills in the metropolitan region were lined and officially put all of them on notice to “clean up their act.” (The Age, September 21, 2008). While publicly stating that they were not aware of similar incidents affecting residential neighborhoods, the EPA began conducting reviews at all other Victorian landfills to see if they posed a significant risk to any neighboring properties (Cooper, 2008). Approximately 300 homes in the Brookland Greens Estate were tested for the gas, and the danger level reduced on October 31, 2008 when the risk to residents was deemed to be at tolerable levels.

Unsurprisingly, a class action lawsuit was filed against the City of Casey, as well as the EPA. A settlement was reached in March 2011 for AU$23.5 million; $13.5 million paid by the city and $10 million by the EPA and $6 million of the total covered legal fees. The 771 residents received payments ranging from $7,000 to $132,000 depending on the severity of the impact to their property, an average of $22,373 each (Schulz and Barber, 2011). A schedule of the incidents is shown in Exhibit 1.

**Methods**

We test for two potential causes of price impacts. Firstly, the analysis of direct impacts to property values surrounding Brookland Greens that resulted from the methane gas leak in August 2008. We then test to see if any indirect or contagion effects are felt at the other landfills that were publicly put on notice regarding potential impacts from methane. As homes surrounding the other landfills were not directly impacted by the initial methane leak in Brookland Greens, any impact on prices surrounding these sites may be attributable to non-spatial contagion.
**Exhibit 1** | The History of the Brookland Greens Estate

<table>
<thead>
<tr>
<th>Year</th>
<th>Incidents and Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>Landfill at Stevenson’s Road operating as a landfill.</td>
</tr>
<tr>
<td>2000</td>
<td>Amendment to planning scheme to rezone land to Residential 1 to facilitate development of the estate; and the Section 173 agreement between Council and PEET stipulated no homes to be built within a 200-meter buffer of the landfill.</td>
</tr>
<tr>
<td>2004</td>
<td>Victorian Civil and Administrative Tribunal (VCAT) hearing that PEET seeking to develop Stage 10 of the estate, and this land was situated within the 200m landfill buffer. VCAT approved the reduction of the buffer along the western side of the landfill boundary.</td>
</tr>
<tr>
<td>2005</td>
<td>Landfill ceased operation.</td>
</tr>
<tr>
<td>March 2006</td>
<td>EPA notified of bubbling stormwater and testing confirmed landfill gas containing methane and carbon dioxide, which was migrating from the landfill into the estate. EPA issued a pollution abatement notice.</td>
</tr>
<tr>
<td>August 2008</td>
<td>Home in Brookland Greens was detected as having Methane gas detected at 63% volume for volume of air.</td>
</tr>
<tr>
<td>September 2008</td>
<td>Residents in the Brookland Greens Estate were evacuated by the Country Fire Authority as the EPA had advised that the methane gas levels posed an imminent danger to residents.</td>
</tr>
<tr>
<td>October 31, 2008</td>
<td>The risk levels were downgraded and residents allowed to move back into their homes.</td>
</tr>
<tr>
<td>September 2008</td>
<td>Complete cessation of demand for rental accommodation in the Brookland Greens Estate was noted; future residents who were building on their land either ceased building activity or suspended construction contracts; businesses operating in homes were unable to continue; residents were unable to obtain or renew policies of insurance for their homes or property in Brookland Greens Estate. 277 homes across the Brookland Greens Estate had landfill gas/methane gas-in house monitoring installed; physical works to 252 homes in the estate were undertaken to mitigate the migration of landfill gas; and physical works comprising the construction of a bentonite diaphragm wall on the perimeter of the landfill (completed September 2009).</td>
</tr>
<tr>
<td>November 2008</td>
<td>Slater and Gordon Lawyers lodged class action on behalf of residents.</td>
</tr>
<tr>
<td>May 2009</td>
<td>Mediation was conducted at the County Court and also the Federal Court.</td>
</tr>
<tr>
<td>February 2011</td>
<td>Date of hearing 1 February 2011 and Date of Ruling, February 3, 2011.</td>
</tr>
<tr>
<td>March 2011</td>
<td>Residents win $23.5 million AUD compensation for the gas leak fiasco, $10 million to be paid by the EPA and $13.5 million to be paid by Casey Council. Residents share $17.25 million after $6 million payment for court costs and legal fees. This equates to approximately payouts from $7,000 to $132,000 for the worst affected households.</td>
</tr>
</tbody>
</table>

*Note: The sources are Brouwer (2009) and Wheelan v. City Council of Casey & Ors (No. 3). 2011.*
Further, we test two different types of landfills: (1) closed and capped and (2) open and active. The sites are distributed throughout the Melbourne area, some in gentrifying neighborhoods, others near industrial areas, and some in more rural parts. While closed, capped, and redeveloped make up the bulk of our analysis, one of the capped, Narre Warren, consisted of undeveloped vacant land at the time the notice was issued. Further, it is important to note that the Brookland Greens case is something of an anomaly in the Melbourne area—the landfill had ceased operations when the contamination was discovered but still possessed a license to operate. The short time frame between those events (about nine months) coupled with homes being within 200 meters of an active, operating landfill for several years prior to the cessation of operations contributes to the unique qualities of the case. Because we recognize that comparing Brookland Greens to closed and capped fills, some of which provide amenities such as parkland to local communities, may not sufficiently address the pertinent questions, evaluation of active landfills is also required.

The problem with active landfills is that few are positioned within 500 meters of a residential neighborhood, the minimum distance recommended by the EPA in their 2001 report. This is to be expected; most developers and homebuyers are wary of investing in properties that may be subject to environmental disamenities, as previously discussed. That said, one site on the list of 35, the Clayton South landfill, is positioned appropriately for analysis. Clayton South is about 32 kilometers from Brookland Greens and is also located in the southeast region of Melbourne. The area is generally less rural than the City of Casey, but would not be considered densely developed.

We use a hedonic modeling framework to test for both the direct and contagion effects. The hedonic model is the method traditionally used to determine the impact of one or more characteristics on the price of housing, thus it is the preferred method for this research. It has been used widely to establish the value of a variety of (dis)amenities since Rosen’s (1974) seminal work on the subject. We use it to compare the prices of homes within 500 meters—the notification distance and the distance recommended by the EPA to minimize the risk of exposure to “dust, noise, windblown litter, and other emissions in relation to the landfill site (EPA, 2001)—to those between 500 meters to 2,500 meters of the landfills. As there are differences in prices between the areas near to the landfills and those farther away prior to the leak and the subsequent announcement, we approach the analysis through a before–after comparison. First, differences in prices between the affected (<500 m) and the control (500 m < 2,500 m) for the period before the leak are estimated. This pre-existing difference is then subtracted from any observed difference post-leak to determine the change in price differentials (if any) due to the leak and/or non-spatial contagion. As an example, if the homes around landfill X sold for 3% less prior to the leak and 12% less after the leak, we would conclude a change in value, or an impact due to the leak of −9%. Both the pre-leak (before) and post-leak (after) periods cover a 32-month span. The before period is from January 1, 2006 to August 31, 2008 and the after period is from September 1, 2008 to April 20, 2011, the date of the Brookland Greens legal settlement.
We use a traditional semi-log hedonic pricing model approach:

\[
\ln(price) = \alpha + \beta X + \gamma t + \lambda L + \epsilon,
\]

where \( price \) is the observed sales price, \( X \) is a vector of physical home characteristics such as number of bedrooms and lot size, \( t \) is a vector of time dummy variables (quarter), and \( L \) is a dummy variable indicating whether or not the home is located within the 500 meter buffer zone of the landfill.

One model is estimated before the leak date (August 31, 2008) and one after. The coefficients\(^5\) for the \( L \) dummy variables, \( \lambda \), from the before and after models are then compared to determine the change in relative price impacts of proximity to the landfill after the leak. This two model, before–after approach is executed first on the Brookland Greens (direct) case and then on the remaining potential contagion landfills. Due to data limitations and landfill locations, only 10 of the 35 notified landfills had enough surrounding residential property sales to estimate potential contagion effects from the initial leak and the subsequent announcement.

We began our analysis by attempting to locate the exact locations of the landfills in the original EPA list. Of the 35 listed sites, 30 were located to an exact parcel(s) level. Of these 30, 9 have been closed and capped and have residential neighborhoods or estates located within 500 meters of the exterior boundary of the landfill and had at least 50 sales of residential properties during the study period. Only one (Clayton South) met the open landfill criteria with the requisite amount of property sales. Exhibit 2 shows the location of each landfill in the Melbourne Metropolitan Area.

The majority of the landfills examined in this study had been, in 2008, redeveloped by the city councils into public amenities such as parks, gardens, sporting facilities, and the like. Consequently, public awareness of landfills in the area might be minimal, because the current uses are considered amenities. Of the sites we investigated, two were vacant and had not been redeveloped and one was partially redeveloped and partially vacant. The others were parks of varying sorts. Details regarding the redevelopment of these sites are found in Exhibit A2 in the Appendix.

**Data**

Our data includes all sales of single-family residential properties from 2006 to 2011. The source of the data is the Australian Property Monitors (APM), obtained through the Australian Urban Research Infrastructure Network (AURIN). The data includes a limited number of characteristics about the physical attributes of the homes: number of bedrooms, number of bathrooms, size of the lot (m²), and the presence of a study. Living area of the home as well as judgments regarding the quality or condition of the home are not commonly found in property data in Australia; this dataset is not an exception.
Unfortunately, the exact latitude and longitude for each home are not available. Home location is available only at the mesh block level. Home sales within mesh blocks that are located within 2,500 meters of the outer boundary of each landfill make up our study area. The lack of exact geolocations does impact our choice of model functions as we are not able to estimate more advanced spatial autoregressive specifications. Exhibit 3 is an example of the size of mesh blocks, which generally contain 30 to 60 homes.

As Exhibit 3 shows, the landfills are widely spread over the Melbourne Metropolitan Area. Home prices in Melbourne also vary considerably based on location, with the outer suburban areas offering markedly cheaper housing than inner city locations. These differences in prices are highlighted in Exhibit 4. Additionally, inner city locations such as Northcote and Farnsworth are composed of smaller homes on smaller lots.

**Results**

The investigation begins with a univariate analysis of prices surrounding each landfill both before and after the announcement date. In most cases, exceptions being Altona, Brookland Greens, and Scotch, the prices in the affected (<500 m) and control (500 m to 2,500 m) areas during the before time period are relatively
Exhibit 3 | Mesh Blocks in the Brookland Greens Area

Exhibit 4 | Summary Statistics: Mean Values

<table>
<thead>
<tr>
<th></th>
<th>Sales Price</th>
<th>Bedrooms</th>
<th>Bathrooms</th>
<th>Lot Size (sq. m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brookland Greens</td>
<td>$319,799</td>
<td>3.48</td>
<td>1.80</td>
<td>628</td>
</tr>
<tr>
<td>Altona</td>
<td>$431,107</td>
<td>3.17</td>
<td>1.56</td>
<td>549</td>
</tr>
<tr>
<td>Box Hill</td>
<td>$784,710</td>
<td>3.18</td>
<td>1.57</td>
<td>610</td>
</tr>
<tr>
<td>Clayton South</td>
<td>$448,387</td>
<td>3.21</td>
<td>1.47</td>
<td>579</td>
</tr>
<tr>
<td>Craigieburn</td>
<td>$341,105</td>
<td>3.45</td>
<td>1.89</td>
<td>538</td>
</tr>
<tr>
<td>Farnsworth</td>
<td>$547,721</td>
<td>2.77</td>
<td>1.34</td>
<td>370</td>
</tr>
<tr>
<td>Green Gully</td>
<td>$392,302</td>
<td>3.35</td>
<td>1.63</td>
<td>649</td>
</tr>
<tr>
<td>Llewellyn</td>
<td>$491,688</td>
<td>3.71</td>
<td>1.90</td>
<td>705</td>
</tr>
<tr>
<td>Narre Warren</td>
<td>$374,988</td>
<td>3.44</td>
<td>1.92</td>
<td>632</td>
</tr>
<tr>
<td>Northcote</td>
<td>$670,923</td>
<td>2.70</td>
<td>1.27</td>
<td>393</td>
</tr>
<tr>
<td>Scotch</td>
<td>$492,946</td>
<td>3.06</td>
<td>1.62</td>
<td>523</td>
</tr>
</tbody>
</table>
Exhibit 5 | Univariate Price Analysis

<table>
<thead>
<tr>
<th>Before</th>
<th>After</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Affected</td>
<td>Control</td>
<td>Affected</td>
</tr>
<tr>
<td>Brooklyn Greens</td>
<td>$377,675</td>
<td>$296,475</td>
</tr>
<tr>
<td>Altona</td>
<td>$440,500</td>
<td>$383,725</td>
</tr>
<tr>
<td>Box Hill</td>
<td>$652,611</td>
<td>$690,900</td>
</tr>
<tr>
<td>Clayton South</td>
<td>$343,390</td>
<td>$391,401</td>
</tr>
<tr>
<td>Craigieburn</td>
<td>$280,364</td>
<td>$305,082</td>
</tr>
<tr>
<td>Farnsworth</td>
<td>$519,305</td>
<td>$475,474</td>
</tr>
<tr>
<td>Green Gully</td>
<td>$329,878</td>
<td>$365,251</td>
</tr>
<tr>
<td>Llewellyn</td>
<td>$427,761</td>
<td>$431,432</td>
</tr>
<tr>
<td>Narre Warren</td>
<td>$387,202</td>
<td>$336,460</td>
</tr>
<tr>
<td>Northcote</td>
<td>$574,909</td>
<td>$594,570</td>
</tr>
<tr>
<td>Scotch</td>
<td>$364,037</td>
<td>$472,786</td>
</tr>
</tbody>
</table>

similar. The existence of price dissimilarities, however, means that we will have to properly control for pre-existing differences in the multi-variate regression analysis.

As seen in Exhibit 5, most areas (both control and affected) saw average prices move around 15% to 30% from the before and after periods. Brookland Greens offers a noticeable departure from this trend as both the affected and control area mean prices only changed 11% and 6% between these two periods. Other notable deviations from the norm include the high price increases in Box Hill and Farnsworth, two areas undergoing rapid gentrification.

We also examine the “stickiness” of house prices in the affected areas. Potential sellers may not simply reduce price to a level at which a buyer can be found, instead—especially if they are owner occupiers—they may choose to forego sale and stay in the home until the market improves (Case and Shiller, 2003; Miles, 2008). As a result, changes in the volume of sales may also signify impacts on markets due to contagion and proximity to a perceived disamenity. Exhibit 6 shows the sales volumes in the affected (<500 m) and control (500 m < 2,500 m) area around each landfill both before and after the leak announcement. Overall sales volumes within 500 meters of the Brookland Greens site declined 18% in the period after the announcement, suggesting a softening of the market. Sales volumes also declined in 7 of the 10 other contagion sites following the leak.

While the univariate analysis may provide interesting context to the situation, it does not account for potential changes in the types of houses that sold in the area or the specific times during the 32-month before and after period that homes sold. To better account for these potential differences, an estimate of a set of hedonic
<table>
<thead>
<tr>
<th>Case</th>
<th>Jan. 2006 to August 2008</th>
<th>Sept. 2008 to April 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;500 m</td>
<td>500 m &lt; 2,500 m</td>
</tr>
<tr>
<td>Brooklyn Greens</td>
<td>113</td>
<td>74</td>
</tr>
<tr>
<td>Altona</td>
<td>110</td>
<td>344</td>
</tr>
<tr>
<td>Box Hill</td>
<td>311</td>
<td>703</td>
</tr>
<tr>
<td>Clayton South</td>
<td>23</td>
<td>878</td>
</tr>
<tr>
<td>Craigieburn</td>
<td>156</td>
<td>394</td>
</tr>
<tr>
<td>Farnsworth</td>
<td>498</td>
<td>864</td>
</tr>
<tr>
<td>Green Gully</td>
<td>204</td>
<td>287</td>
</tr>
<tr>
<td>Llewellyn</td>
<td>217</td>
<td>271</td>
</tr>
<tr>
<td>Narre Warren</td>
<td>289</td>
<td>468</td>
</tr>
<tr>
<td>Northcote</td>
<td>595</td>
<td>950</td>
</tr>
<tr>
<td>Scotch</td>
<td>407</td>
<td>306</td>
</tr>
</tbody>
</table>
Hedonic Price Models

In the hedonic price modeling exercise, we analyze the impact of the landfill contamination on the Brookland Greens housing estate. The results of both the before and the after models are shown in Exhibit 7. Overall, the models offer a relatively low R-squared; however, the standard errors are between 12.9% and 12.1%. These low standard errors suggest that the models do fit the data well. The coefficients all have the expected sign, with the exception of a few insignificant coefficients on some of the structural characteristics. Note that the presence of a study in the house acts primarily as a proxy variable indicating a higher quality home or one that has been remodeled (as a direct quality variable is not available in our data).

Brookland Greens

Looking specifically at Brookland Greens, it is apparent that in the before time period, the area within 500 meters of the landfill was worth, on average, 13.2% more than the control area. After the announcement of the methane leak, this difference dropped to 11.2%, a decrease in relative prices of 1.9%. This decrease represents the average difference in relative value between the two periods, before and after the announcement date.

Capped and Redeveloped Landfills. Next, the same methodology is employed on the other ten notified landfills. The results of this analysis are shown in Exhibit 8. For five out of the nine landfills, there was no statistically significant difference
in prices (once home characteristics were controlled) between affected and control areas in either the before or after time periods. In the remaining five cases, three sites—Craigieburn, Farnsworth, and Scotch—showed moderate price increases while prices near Narre Warren decreased 5.3%, relatively speaking, in the time period after the announcement date.

**Open Fill: Clayton South.** When the analysis is replicated for the Clayton South site, the results show that the homes within the 500-meter buffer are selling at an 8% discount, post notification. When the affected distance is increased to <1,000 meters, a decrease in value of 0.79% is observed.

## Conclusion

Our original research question is based on an expectation that when information regarding an unexpected, detrimental event, in this case the discovery of methane gas at a housing development adjacent to a landfill, is released, a diminution in value will occur. We further posit that effects may also be present at similarly situated sites that are not directly affected by the event (i.e., non-spatial contagion). The analysis of the direct event involving the methane leak in the Brookland Greens Estate shows a 1.9% relative decline in prices in the period after information regarding the leak was made public. This diminution in value is expected as the methane leak represents an identified disamenity for homeowners in the area.

The test for non-spatial contagion in the nine capped landfills and one open site located in heavily residential areas throughout the metropolitan region identified no systematic reduction in residential house prices during the period immediately after the event. Two of the sites, Narre Warren and Clayton South, show declines
in prices, while three others show increases. Five of the sites exhibited no change in relative values between homes near the closed landfills and those farther away. In other words, there appears to have been no measurable, sustained contagion effect in the closed and capped market around landfills. There are a number of reasons for this null finding.

First, many of the covered landfills are currently operating as environmental amenities—parks, sporting facilities, and golf courses—and as such their prior use as landfills may not be evident to potential homebuyers. Even if potential homebuyers have been made aware of recent issues with capped landfills generally, they may not realize a fill is near the property they are buying. Sellers, agents, and local officials are under no obligation to disclose the issue to buyers, therefore information diffusion is likely low in these cases (provided the property is not directly affected by negotiations between the city council and developer as would be noted in a Section 173 Agreement).

Limitations to the data may also reduce the reliability of the results as the inability to accurately locate home sales to exact geographic locations could be obscuring actual diminutive effects. In other words, homes located within a few hundred meters maybe be negatively affected. However, this impact is overwhelmed by the lack of impact from homes farther away, all of which are aggregated to the mesh block group level.

One of the basic assumptions flowing through this study is that local residents’ knowledge about contaminated land is similar to that of professionals—they react to news of pollutants systematically. This implies that communities react to landfills in the same way (i.e., the reactions are homogeneous and directly comparable). This study is based in a number of diverse communities with a variety of (dis)amenities present. These local factors may be overriding any evidence of non-spatial contagion from the Brookland Greens site, if the contagion even exists. Additionally, because landfill sites are normally developed post-closure and not prior, there may be less of a social impetus and fewer communication networks to motivate collective fear and price drops. Even though the sites were all put on notice by the EPA and a fair bit of information was made available via formal networks (e.g., local newspapers, television newscasts), it is unclear how much of this information effectively reached the affected population. It is possible that the areas that sustained a negative impact (Clayton South and Narre Warren) had stronger and more viable social networks to transfer information, thus contagion effects may be evident there. It is also possible that the buyers interested in these two suburbs were more risk adverse with more alternatives available to them.

The evaluation of the closed and capped sites provides interesting insight into “who knew what when.” Local councils in Melbourne are arguably skillful and motivated to convert and cover landfill site surfaces. Many of the closed and capped sites have been redeveloped into parkland, golf courses or other amenities that the casual observer would never recognize as a former landfill. It is rational for local councils, developers, and the EPA to control circulation of or passively slow down information to counteract social networks and whether intended or not,
capping and covering a landfill does just that. The removal of visual evidence has the potential to impair social memory, negatively impacting any associated communication networks, or to simply create new and different ones.

While we recognize that two cases do not provide conclusive evidence of a systematic pattern of contagion, the results for Clayton South and Narre Warren are interesting. As an open landfill, Clayton South possesses the characteristics that suggest it is most like Brookland Greens. When analyzed, there is evidence, albeit limited, that the contagion sparked by the Brookland Greens case may be present. While sales volume increased modestly (0.53%), property values were depressed by over 8%. It is entirely plausible that the increase in volume was motivated by the relative decrease in price. Narre Warren was the only capped site that consisted of vacant land that had not been redeveloped and the surrounding properties show a diminution in value, along with a reduction in sales volume. Neither Clayton South nor Narre Warren possessed the amenity effect of the capped and redeveloped fills that were parks or sporting facilities at the time of notification. This suggests that the effects of a single event, regardless of how detrimental they are perceived to be at one site, are not distributed equally across markets.

Appendix

Exhibit A1 | EPA Designated Landfill Types

<table>
<thead>
<tr>
<th>Landfill Type</th>
<th>Landfill Description</th>
<th>Buffer in Operation</th>
<th>Buffer Post-closure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>Prescribed industrial wastes.</td>
<td>Not disclosed as part of different guidelines</td>
<td></td>
</tr>
<tr>
<td>Type 2</td>
<td>Putrescible (municipal) waste, solid inert waste and fill material. Can include category C industrial waste if licensed.</td>
<td>500 meters from buildings and structures&lt;sup&gt;a&lt;/sup&gt;</td>
<td>500 meters from building or structures</td>
</tr>
<tr>
<td>Type 3</td>
<td>Solid inert waste, fill material.</td>
<td>200 meters from buildings and structures</td>
<td>200 meters from buildings and structures</td>
</tr>
</tbody>
</table>

Note:

<sup>a</sup>In the VCAT hearing in regard to the Stevenson’s Road Landfill site and the Brookland Greens Estate, VCAT ruled that the 200-meter buffer distance was to be measured from the “active tipping area,” being the “active tipping face” of the landfill.
## Exhibit A2 | Landfills

<table>
<thead>
<tr>
<th>Landfill Site</th>
<th>Status</th>
<th>Date Ceased Operations</th>
<th>2008 Use</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Queen Street Altona</td>
<td>Closed</td>
<td>1998</td>
<td>Park</td>
<td>75 hectares of parks and wetlands.</td>
</tr>
<tr>
<td>14 Federation St., Box Hill</td>
<td>Closed</td>
<td>1999</td>
<td>Park</td>
<td>Parkland, sporting reserves and vacant land, 2006 permit granted for development of residential to part of the site.</td>
</tr>
<tr>
<td>Craigieburn Gardens, Craigieburn</td>
<td>Closed</td>
<td>Unknown</td>
<td>Park</td>
<td>In 2007 the site was already developed, as a park, partial leisure center and community facilities. BBQ picnic area, shelter, not well maintained, mostly unstructured open space. There are no known records of the type, depth, compaction or other treatment of fill in the landfill (Hume City Council, 2007).</td>
</tr>
<tr>
<td>Quarry Park, Farnsworth Ave., Footscray</td>
<td>Closed</td>
<td></td>
<td>Park</td>
<td>Parkland, nearby city college, and other sporting amenities.</td>
</tr>
<tr>
<td>Clarke Rd., Springvale South</td>
<td>Closed</td>
<td>2002</td>
<td>East of Clarke Rd. is Park, west of Clarke Rd., vacant land</td>
<td>High levels of methane detected in bored holes adjacent to community building and residences on southern boundary. This was a capped (or poorly capped landfill at this time) EPA issued a new notice in Dec 2008. It was noted that although permissions for use as a rubbish tip expired in 1998, this site was used up to 2009 to stockpile scrap concrete (EPA, 2009).</td>
</tr>
<tr>
<td>151 Green Gully Road, Keilor Downs</td>
<td>Closed</td>
<td>Unknown approximately 30 years ago (Brimbank City Council, 2013)</td>
<td>Park</td>
<td>The Green Gully Reserve is a 69 hectare site and has been established for some time, noted as the Council’s second largest recreational sites with six sports grounds. Landfill gas issues are not considered to be a problem given the age of the landfill (Brimbank City Council, 2013).</td>
</tr>
<tr>
<td>Llewellyn Park, Wantirna South</td>
<td>Closed</td>
<td>1980s</td>
<td>Park and sporting reserve</td>
<td>The parklands and reserve were developed after the closure; however, exact dates cannot be located. Residents were notified due to high levels of gas post 2008 Stevenson’s Road report.</td>
</tr>
<tr>
<td>Quarry Road, Narre Warren North</td>
<td>Closed</td>
<td>1996</td>
<td>Vacant land</td>
<td>This site was previously a Type 2 landfill operating since 1982, it was used as a landfill gas power station from 1992 until 1996 when it was closed.</td>
</tr>
<tr>
<td>Clifton Road, Northcote</td>
<td>Closed</td>
<td>Early 2000s</td>
<td>Park</td>
<td>Former quarry used as a local landfill, classified as a Type 2 landfill. Redeveloped into major 13 hectare regional park in 2002 known as “All Nations Park.”</td>
</tr>
</tbody>
</table>


**Exhibit A2** | (continued)

<table>
<thead>
<tr>
<th>Landfill Site</th>
<th>Status</th>
<th>Date Ceased Operations</th>
<th>2008 Use</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scotch Pde, Chelsea</td>
<td>Closed</td>
<td>1970s</td>
<td>Park</td>
<td>The park was developed in the 1980's and was completed in 1988. This site has several redevelopments with other facilities included over time with sporting fields, community center and clubs.</td>
</tr>
<tr>
<td>Stevenson’s Road, Cranbourne</td>
<td>Closed</td>
<td>2005</td>
<td>Vacant land</td>
<td>Residents are unaware of landfill in contract of sale and S173.</td>
</tr>
<tr>
<td>Clayton South</td>
<td>Open</td>
<td>N/A</td>
<td>Landfill Type 2</td>
<td>Residents are aware of landfill and make regular complaints about the odor, with regular updates and community newsletters sent via the EPA and City of Kingston. Furthermore the local “Leader” newspaper has regular articles on the landfill sites in the area.</td>
</tr>
</tbody>
</table>

**Endnotes**

1. The EPA provides a number of guideline documents in regard to landfill sites in Victoria. There are two main documents: Best Practice Environmental Management—Siting, Design, Operation and Rehabilitation of Landfills and Industrial Waste Resource Guidelines. These guidelines classify the type of landfill, and what type of landfill can be disposed of, consequently the guidelines regarding siting, design, operation, and rehabilitation change depending on the classification. The purpose of the buffers is to manage the odors from the landfill (a key concern during the operational phase of a landfill) and landfill gas, which may be an explosion risk and/or asphyxiation risk up to 30 years post closure of the landfill) (EPA, 2015).

2. In the 1991 State Environment Protection Policy (Siting and Management of Landfills Receiving Municipal Wastes) document produced by the EPA, the required distance was 200 meters but due to the number of complaints regarding odors from various fills, the EPA was motivated to change that distance to 500 meters.

3. Residential land subdivisions in Australia are commonly set up to be completed in stages, particularly when they are large subdivisions or estates. This allows efficient site development and sale of lots in a process that provides a feeding of lots into the market without flooding it and creating an oversupply. Most importantly, the staged process assists the funding of the development, as when a stage is complete the land lots can be settled, providing the developer with income and cash flow to continue and fund the following stages.

4. In Victoria, the sale of land provides a contract in which all salient details of a property are to be disclosed. The Section 173 Agreement includes any agreements between a developer and the city council, which are then incorporated into any further contracts for
the sale of land. The S173 Agreement for the Brookland Greens development failed to
disclose the site’s vicinity to the landfill, referring to it instead as “sand extraction
operations.”

5 After properly adjusting for dummy variables derived from a semi-log model; exp(c) – 1 (Halvorsen and Palmquist, 1980).
7 www.aurin.org.au.
8 Mesh blocks are small geographic aggregations containing about 50 homes used by the
Australian Bureau of Statistics for census purposes.
9 Individual regression results are available upon request.

References


Winston-Geideman, Krause, Wu, and Warren-Myers


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Green Tax Incentives and Other Demand Factors Motivating Green Commercial Property Investment


Abstract  In this study, we seek to identify and model the motivating factors that influence developers’ and investors’ decisions to invest in green commercial properties using structural equation modeling methods. Specifically, we model the effects of green building skills and green tax incentives on demand factors influencing green commercial property investment. The study is based on a survey of 350 real estate developers in Malaysia. The results show that monetary green tax incentives and green skills have significant casual effects on demand. Among these, personal and altruistic environmental motivations, corporate conscience responsibility motivations, and economic and financial motivations are significant. Green tax incentives, however, are found to have the most significant effect on green commercial property demand and investment.

There is a general understanding among those knowledgeable with the subject matter that green building investment offers a path to environmental impact mitigation and reduction in energy use and consumption (Miller, Pogue, Saville, and Tu, 2010; Aliagha, Maizon, Afeez, and Ali, 2013; Chequt, Eichholtz, and Kok, 2014; Kok, 2014). Whereas the process is complex and by no means explicit, the understanding is however based on the large environmental and socioeconomic footprint of green building, especially when considering the high reliance on energy and water saving, as well as reduction in the operating cost. In the meantime, we have evidence that the value of a building can be connected to the building’s apparent level of sustainability (Miller, Pogue, Gough, and Davis, 2009; Reed, Bilos, Wilkinson, and Schult, 2009; Kok, 2014). In addition, Chequt, Eichholtz, and Kok (2014) show that green building investment is situated within the marketplace that is influenced by many other forces of demand and supply, where the stakeholders include the real estate development team, building owners, and tenants etc. They observe that attention to sustainability and energy efficiency in green building has gradually shifted to building owners, tenants, and investors who are considered to represent conduits for achieving energy efficiency in building investment.
While we agree that this shift in perception is gradually moving the green property market towards increased levels of energy efficiency and sustainability, we equally add that stakeholders in the green building industry are not fully aware or less certain of the motivating factors and benefits of green building. Whereas debates on the environmental benefits of green building are gradually becoming less contentious, the pressing concern for potential occupants and investors in green building are buildings that can reduce environmental footprints, energy use, and operational costs, enhance employee productivity, and promote a collaborative and innovative workplace while at the same time achieve core rental profit and values (Miller, Pogue, Gough, and Davis, 2009; O’Mara, 2012; Chequt, Eichholtz, and Kok, 2014; Nurick et al., 2015).

On the other hand, the top building related issue that worries society most is the growing evidence that the building sector is a major consumer of resources and energy, accounting for about 44% of society’s total material use and more than 50% of primary resources (Nelms, Russell, and Lence, 2005). For example, energy consumption by building in Canada, United Kingdom, and the United States is 30%–50% of the country’s total energy demand (Nelms, Russell, and Lence, 2005). Commercial properties contribute significantly to this resource demand. Commercial buildings (offices, retail, and industrial) consume close to 20% of the total energy consumption (Kroll, 2011). Indeed, we have observed increases in green commercial building investment and demand. A green building (also known as green construction or sustainable building) whether residential or commercial refers to both a structure and the using of processes that are environmentally responsible and resource-efficient throughout a building’s life-cycle (Kriss, 2014).

Green building development and lifetime operation offers the healthiest conceivable environment while guaranteeing the most productive and least disruptive use of land, water, energy, and resources (Governor’s Green Government Council, 2010). While there are many different definitions of green building, it is generally accepted as the planning, design, construction, and operation of buildings with foremost consideration of energy use, water use, indoor environmental quality, material selection, and the building’s onsite effects (Kriss, 2014).

The concept of green building we largely believe underscores investment in environmental and eco-friendly property for the purpose of achieving environmental, social, and economic benefits. However, green building demand and investment is still low despite the availability of the market (Nazriah, 2010; Aliagha, Maizon, Afeez, and Ali, 2013; Yudelson, 2016). This situation may in part be due to prospective investors and users who are not completely mindful or still less sure of the expected returns for green building, which may include non-quantitative returns. For example, a prospective environmental risk-averse client or tenant would be more likely to demand sustainable building if he is aware of the driving benefits accruable from it.

Studies show that investors who are knowledgeable about the factors that motivate green building are more likely to realize greater benefits and market returns on green investment (Miller, Pogue, Saville, and Tu, 2009; Alev and Baabak, 2010; Nurul and Zainul, 2013; Kok, 2014). Thus, knowledge could motivate more green
building demand and be a good step towards avoiding harmful activities on the environment while improving the social and economic welfare of investors. For example, occupants and investors are likely to demand green building due to their belief that climate change is real and should be mitigated (Aliagha, Maizon, Afeez, and Ali, 2013).

To what extent are investors and occupants aware and knowledgeable about social and economic drivers of green building? Recent studies on green building seem to focus on green residential buildings (Christopher, 2007), government and institutional green buildings (Shahamir and Zakara, 2014), and energy efficiency (NgBan and Zainal, 2013). Although green commercial properties are gradually becoming areas of research interest, studies focusing on green commercial properties (Wade, Petty, and Ramsay, 2003; Fuerst and McAllister, 2009; Miller, Pogue, Saville, and Tu, 2009; Chequt, Eichholtz, and Kok, 2014) seem to focus mainly on green building certification, energy efficiency, eco-labelling, green building, and productivity without specific attention to the interdependent factors that underlie the demand for green commercial property investment.

Moreover, studies that examine the correlations among the green demand drivers appear to be few (Numraktrakul, Ngarmyarn, and Panichpathom, 2011; Mohd, Milad, and Nariman, 2013). Investors and stakeholders are not only interested in correlations but also which variables such as monetary green tax incentives and available green skills have the most causal effects on the nature of demand for green building factors. Investors and consumers seem to be naïve or skeptical, otherwise there would be more green building demand by now. Developers seem even less certain of the economic, environmental, and social benefits from green building. Against this backdrop, we argue that if commercial green building makes environmental, economic, and social sense as acknowledged by experts, which factors and influences are most important? As such more empirical studies that focus on the demand factors of green commercial property investment is required. It is our contention and opinion that investigations into the area will benefit investors, developers, and other stakeholders involved in green building development. Thus, the objectives of this study are: (1) identify and validate the factors that could affect the demand for green commercial property investment and (2) determine the causal effect of monetary green tax incentives and available green skills on personal and altruistic environmental motivations, corporate conscience responsibility motivations, and economic and financial motivations in relation to green building demand and investment.

**Review of Related Theory and Literature**

**Related Theory on Decision to Demand Green Building**

Social cognitive theory (SCT) is one popular behavioral theory that can be used to explain the decision and motivation to invest in green building. SCT is a psychological model used to explain the motivations, expectations, forethought, desires, and responsibility that could prompt and direct an individual’s activity. As it concerns green building demand and investment, SCT holds that before
investors become involved in green building for any reason or purpose, they are motivated by certain factors. However, motivation is dependent on the aim and benefits identified through the thought process particularly when the knowledge of green building is an emerging concept (Nurul and Zainul, 2013). For instance, if investors envision the presumable results of an impending environmental disaster, they will set objectives and plan a course of action that is likely to protect their immediate surroundings by going green.

Nevertheless, the reality of climate change has increasingly dominated the campaign and motivation for more investment in green building. Thus, investors with the right motivations and expectations are attracted to green building based on personal or altruistic environmental reasons, social or corporate conscience responsibility, and/or financial or profit maximization. Moreover, SCT scholars have argued that investor incentives such as tax credits, loans or grants and subsidies, tax abatement, property tax credits, low capital gains, and/or low stamp duties could motivate investors to invest in green building. Government capacity to incentivize green products woo investors to demand green buildings (Nurul and Zainul, 2013).

Factors that Motivate Investors to Commit to Green Building

Personal and Altruistic Environmental Motivations

Environmental altruism is providing or participating in ecological activities to gain internal and self-reward instead of external reward (Baston, 2008). By this definition, we argue that an environmental risk-averse consumer’s decision to be comfortable and avoid imminent ecological hazards could be based on personal and altruistic motivations. Also, we have evidence that pro-environmental concern based on altruistic motivation and perception advocates for green buildings that minimize the consumption of large resources such as water, energy, and materials while improving the thermal and acoustic environment of a building (Singh, Syal, Grady, and Korkmaz, 2010; Roa et al., 2012). Furthermore, green building that minimizes solid waste and maximizes the safety, health, and quality of life of the occupants is perceived as altruistically significant (Aliagha, Maizon, Afeez, and Ali, 2013). For example, Roa et al. (2012) find that the quest for thermal comfort and a quality acoustic environment influence people to demand green commercial property. Their assertion is based on investigation that most conventional properties by their nature are often associated with low worker productivity and a poor acoustic environment, which leaves tenants and users irritable and distracted (Miller, Pogue, Saville, and Tu, 2009).

Aliagha and Yin (2013) observed that personal and general altruistic motives are the key factors for energy conservation behavior. Personal norms that lead to pro-environmental action are activated by the belief that the environmental situation may threaten things an individual values and that this person can act to reduce the threat. Linking this to our study, we posit that in order to maintain thermal
comfort in a real estate organization while wearing business suits and neckties, the prevalent attitude and habit of most workers has been to set office air conditioning systems to a temperature as low as 20°C. However, with growing environmental awareness and consciousness, office workers are developing pro-environmental beliefs that may be attributed to altruistic or personal moral norms and values. For example, some office workers may be participating in energy conservation measures not only because it saves energy and money, but because of their altruistic belief that climate change and its effects on humans and the environment are real and they can act to reduce these effects (Aliagha and Yin, 2013). Even when some may not believe or understand climate change, they may still feel morally obliged to engage in energy conservation because their friends and colleagues expect them to do so, or their boss expects them to comply because it is part of the organization’s social responsibility and green work style to conserve energy and reduce their carbon footprint.

**Corporate Conscience and Responsibility Motivations**

Subjective evidence suggests that green building investment is considered a social process of meeting corporate responsibility. Tenants demand for green real estate is due to enhanced reputation benefits and corporate social responsibility (Kok, Miller, and Morris, 2012). According to Kok, Miller, and Morris (2012), such a move in tenant penchants for green building could mean that tenants are using the buildings they occupy to communicate their corporate vision to shareholders and employees. The inference is that social factors could stimulate the motivation and decision to undertake socially desirable actions such as going green. Thus, ethical responsibility of caring for the environment and social pressure to meet the needs of communities and organizations could motivate the demand for green building. For example, in many countries, people want to live in nice and safe homes surrounded by abundant green space and close to transportation and their workplace (Heerwagen, 2000). As reported by Guild Quality (2013), the cognitive motivating decisions to curtail strains on local infrastructures in a community could be regarded as social responsibility. Such motives may be driven by the intention to minimize the damage on structures such as landfills, water sources and drains, reclaim and produce green space, expand transportation routes, and reduce road repairs (Ian, 2010). Linked to this is user satisfaction, reduction in absenteeism, and the ability to attract and retain workers (Isa, Rahman, Sipan, and Hwa, 2013; Nduka and Ogunsanmi, 2015).

**Economic and Financial Motivations**

Another commonly attractive motivation for green commercial building investment is economic and financial benefits. The intention of a potential green commercial property investor is to get a reasonable rate of returns from an investment. This benefit may not necessarily be in the form of cash but other soft-cost benefits. However, the initial cost of investing in green commercial property may be higher than for a typical property. This is because various variables such as the cost of building and building certification may come into play. However, the initial costs are easily recouped within the lifecycle of the building (Nurick et al., 2015).
Advocates of this have justified their assertion on the operating cost reduction of green buildings related to water and energy consumption, as well as the improved performance of building tenants (Miller and Pogue, 2009; Kok, 2012; Nurick et al., 2015). Thus, the advantages of green buildings are not only the cost benefits resulting from energy savings but also the possible residual value of the property (Popescu, Bienert, Schutzenhofer, and Boazu, 2012).

Experts say that green building goes beyond optimizing the lifecycle economic performance of the building to securing grants and subsidies, improvement in employees productivity and satisfaction, as well as securing higher rents and increase resale value (Miller, Pogue, Saville, and Tu, 2009; Bowyer et al., 2013; Aliagha, Maizon, Afeez, and Ali, 2013; Nurul and Zainul, 2013). Miller and Pogue (2009) analyze the operating costs, energy impact, worker productivity, and tenant attitudes using 154 green buildings and over 700 tenants who moved into primarily ENERGY STAR-labeled buildings. They show that many tenants find such space more productive, and that green buildings do save money on energy costs. Moreover, the literature on green buildings, which mostly focuses on new construction, shows a positive relation between green commercial building and financial returns. For example, Eichholtz, Kok, and Quigley (2010, 2013) largely find positive effects on market rents and selling prices on certified office buildings in the U.S. In addition, Fuerst and McAllister (2009) and Miller, Pogue, Saville, and Tu (2009) suggest that there are positive economic and financial related benefits from quicker absorption, higher occupancy rates, lower operating expenses, higher residual values, and higher worker productivity in green building investment.

**Data and Methods**

**Data and Participants**

When trying to identify and select individuals or groups of individuals that are especially knowledgeable about or experienced with a phenomenon of interest, the key and appropriate sampling procedure often considered is the purposive sampling technique. Our focus of inquiry is to sample those who are knowledgeable and experienced in the subject matter. The participants we selected are knowledgeable about the subject matter. We used stratified sampling to select these participants. Stratified sampling involves a process of stratification segregation of population nests or for investigation into strata or categories. We opted for stratified sampling to ensure adequate and better representation. We deviate from previous studies and base the unit of analysis in our study mainly on the perspective of the real estate development team rather than occupants. Thus, our research participants are real estate developers, investors, architects, estate surveyors and valuers, builders, and town planners who are involved and knowledgeable in green building development and investment. They mainly constitute the real estate development team.

Given the greater concentration of potential research participants, Malaysia’s major urban city Kuala Lumpur was chosen as the target for our survey. We
distributed a total of 400 sets of questionnaires among the classes of potential participants. Out of the 400 we distributed, 361 were received, 39 were not returned. Out of the 361 we received, we rejected 11 because of incomplete responses. Moreover, they were not properly complete. We used the remaining 350 for our analysis. In drawing the samples for this study, we referred to Krejcie and Morgan’s (1970) decision model. It is a research instrument that provides a generalized scientific guide and table for sample decisions. It is argued that were the samples are broken into sub-samples, a minimum of 30 for each category is necessary and that in multivariate research, the sample size should be larger. Given this modifying factor, the sample size for this study is 350. The sample size is considered appropriate to take into account the different sub-samples and also to meet the statistical requirements of the multivariate techniques we employ.

Questionnaires were administered face-to-face. Several visits were made and reminders sent including phones calls. The study included incentives to motivate people to respond to the questionnaires. However, those who had no time to complete the questionnaires either immediately or after the second and third appointments were given self-addressed stamped envelopes or email addresses to return the questionnaires. The academic background of the 350 respondents is as follows: post-graduate 22.6%, degree 47.7%, and diploma 29.7%. Thus, it is evident that the respondents have either a university or polytechnic education. The response rates show that developers constituted 30.1%, architects 23.6%, estate surveyors and valuers 18.6%, investors 12.3%, builders 12.0%, and town planners 4.0%. On years of professional experience, the respondents had the following: 2–3 years 9.1%, 3–4 years 15.4%, 4–5 years 21.1%, and 5 years and above 54.3%.

**Instrument and Measures**

The questionnaire was divided into two parts. The first part contained general demographic questions designed to tap into the participants’ background information. The second part comprised a set of questions that were intended to shed light not only on the participants’ awareness of the green properties but also on factors that could motivate green commercial property demand. In this part of the questionnaire, respondents were asked to specify the levels of importance they attach to the variables using a 5-point Likert scale. Five factors and their measures for validation are shown in Exhibit 1. The items were selected to elicit measurements of the five factors because both the theory and literature support them.

**Structural Equation Modeling**

When attempting to analyze the inter-relations among multiple variables in a model, the key statistical technique often used is structural equation modeling (SEM). SEM allows a set of relation between one or more independent or dependent variables to be examined (Zainudin, 2012). Our key objective of using SEM is to analyze the pattern of sequence and structure of inter-related dependence relations between a set of latent or unobserved constructs, each measured by one or more observed variables (Shammout, 2007; Zainudin, 2012).
### Exhibit 1 | Factors and Their Measures for Validation

<table>
<thead>
<tr>
<th>Factor</th>
<th>Variables</th>
</tr>
</thead>
</table>
| **Factor 1: Personal and altruistic environmental motivation measures (PAEM)** | Enhanced energy efficiency and CO$_2$ reduction (PAEM1)  
Improved water efficiency (PAEM2)  
Thermal comfort and quality acoustic environment (PAEM3)  
Reduction of solid waste and minimize site impact (PAEM4) |
| **Factor 2: Corporate conscience responsibility motivation measures (CCRM)** | Users’ satisfaction and more control over the environment (CCRM1)  
Minimization of strain on local infrastructure (CCRM2)  
Reduction in absenteeism (CCRM3)  
Boosts creativity, higher morale, and lower workforce turnover (CCRM4) |
| **Factor 3: Economic cum financial motivation measures (EFM)** | Optimization of life cycle economic performance (EFM1)  
Securing grants and subsides (EFM2)  
Improvement in employees’ productivity and satisfaction (EFM3)  
Securing higher rents and increased resale value (EFM4) |
| **Factor 4: Available green skills (AGS)** | Design skills (AGS1)  
Construction skills (AGS2)  
Maintenance skills (AGS3)  
Procurement skills (AGS4) |
| **Factor 5: Monetary green tax incentives (MGTI)** | Tax abatement and fee waiver (MGTI1)  
Grants, loans and rebates (MGTI2)  
Property tax credit incentives (MGTI3)  
Low capital gains tax (MGTI4)  
Low stamp duties (MGTI5) |

**Notes:** Factor 4 (AGS) and 5 (MGTI) were used to determine or predict level of causal effect on personal and altruistic environmental motivation PAEM; corporate conscience responsibility motivation CCRM and economic and financial motivation EFM aggregated as F1. AGS and MGTI are aggregated as F2 and F3 respectively in the structural model (see Exhibit 5).

Basically, we used SEM to build a concept of causal relations where a modification in one variable, hypothetically effects a change in an alternative variable. Furthermore, we adopted SEM to measure and evaluate the validity and reliability of each construct and to check the overall goodness-of-fit of the model. We did this to ensure that the model fits the data adequately. In conducting the SEM, we used a measurement model to test the convergent and discriminant validity, as well as construct and determine the item reliability of the constructs. We used the SEM to predict the causal relations of the factors, in addition to testing of the hypothesis.

However, it is important to note that there are series of fit indices that are essential when reporting the fitness of a model. Although there is no agreement yet among
Exhibit 2 | Convergent Validity for Demand Factors of Green Commercial Property Investment

<table>
<thead>
<tr>
<th></th>
<th>PAEM</th>
<th></th>
<th>CCRM</th>
<th></th>
<th>EFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>0.622</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>F2</td>
<td>—</td>
<td>0.687</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>F3</td>
<td>—</td>
<td>—</td>
<td>0.560</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>F4</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.591</td>
<td></td>
</tr>
</tbody>
</table>

scholars as to which fit indices should to be reported. Thus, we adopted the most generally used fit indices to assess the models. This we believe provides a detailed reflection of goodness-of-fit as suggested by Hair et al. (1995). The measures include the following: chi square ($\chi^2$) in AMOS, goodness-of-fit index (GFI), comparative fit index (CFI), Tucker-Lewis index (TLI), root mean square error of approximation (RMSEA), adjusted goodness-of-fit index (AGFI), and normed fit index (NFI). Various levels of acceptable thresholds have been suggested by different authors. For GFI, Hair et al. (1995) suggest an acceptance level of 0.90 as appropriate. For CFI, Chau and Hu (2001) view a threshold of ≥ 0.8 as acceptable whereas Schreiber et al. (2006) suggest 0.09 or greater. For RMSEA, Hair et al. (1995) recommend a commonly acceptable value ranging from 0.05 to 0.08. Comparable to GFI, Hair et al. (1995) also suggest a level of 0.90 as acceptable for AGFI, while a generally suggested threshold of 0.90 or greater is acceptable for NFI (Hair et al., 1995; Byrne, 2010).

Results

Measurement Model

As shown in Exhibit 1, we identified the items that measured the constructs and factors affecting the demand for green commercial properties. The representative variables in Exhibit 1 represent each construct. We measured and validated them. We tested them for convergent and discriminant validity, as well as construct and item reliability (see Exhibits 2, 3, and 4). We found that some methods have been recommended for assessing convergent and discriminant validity. They include
factor analysis, correlation, and even more advanced techniques including confirmatory factor analysis (CFA) existing in SEM. In addition, we used AVE as an indicator for supporting convergent validity (Shammout, 2007).

**Convergent Validity.** We achieved the convergent validity of the model when we found that all items in the measurement model were statistically significant. We found that all the variables measuring the same factor or constructs were significant. This evidence supports the convergent validity of the variables (Anderson and Gerbing, 1988). We conducted the convergent validity (CV) using 12 items that measured four different factors and constructs. Constructs F1, F2, and F3 are measured using 4 items respectively. This is structurally shown in Exhibit 5. All the items loaded on their respective factors with most loadings above 0.08 (see Exhibit 2). Also, the statistical significance of each path correlation coefficient for all the exogenous or independent factors (F1, F2, and F3) show that the factors are significantly correlated. To demonstrate convergent validity, the scale of the direct structural relation between the item and the latent construct (or factor) is measurably different from zero. In addition, the items loaded highly on one factor with a factor loading of 0.50 or greater (Holmes-Smith, Coote, and Cunningham, 2006; Shammout, 2007).

**Discriminant Validity.** We also check the discriminant validity of the model. The discriminant analysis was done to confirm if the values of the correlation coefficient between pairs of constructs are significantly different from unity or perfect correlation (Sekaran, 2000; Shammout, 2007). To test the discriminant validity, we paired each of the constructs and simultaneously analyzed them and extracted the average variance. For example, to test the discriminant validity of

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**Exhibit 3 | Average Variance Extracted Test for Discriminant Validity**

<table>
<thead>
<tr>
<th>Pairs of Factors</th>
<th>Aver. Variance Extracted</th>
<th>Squared Correlations ($\phi^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F3 EFM</td>
<td>0.65</td>
<td>0.45 (0.202)</td>
</tr>
<tr>
<td>F2 (CCRM)</td>
<td>0.61</td>
<td></td>
</tr>
<tr>
<td>F3 EFM</td>
<td>0.65</td>
<td>0.64 (0.409)</td>
</tr>
<tr>
<td>F1 (PAEM)</td>
<td>0.66</td>
<td></td>
</tr>
<tr>
<td>F2 CCRM</td>
<td>0.61</td>
<td>0.60 (0.360)</td>
</tr>
<tr>
<td>F1 (PAEM)</td>
<td>0.66</td>
<td></td>
</tr>
</tbody>
</table>

**Exhibit 4 | Test of Construct Reliability**

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Cronbach's Alpha</th>
<th>Aver. Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1 PAEM</td>
<td>0.602</td>
<td>0.66</td>
</tr>
<tr>
<td>F2 CCRM</td>
<td>0.547</td>
<td>0.61</td>
</tr>
<tr>
<td>F3 EFM</td>
<td>0.637</td>
<td>0.65</td>
</tr>
</tbody>
</table>
constructs “F3 (EFM) and F2 (CCRM),” we paired and compared them and their average variances were extracted. If the pattern structure of the coefficients to determine whether measured factors are distinguishable, it indicates the discriminant validity of the two constructs (Sekaran, 2000; Shammout, 2007). Thus, as summarized in Exhibit 3, the average variances we extracted for the four factors are all larger than the squared pairwise correlated for the three factors. We therefore conclude that the three constructs or factors exhibited discriminant validity.

**Construct and Item Reliability.** To determine the degree of reliability of the measurement model in measuring the intended latent construct (Zikmund, 2003), we checked the internal consistency of the item reliability. We used Cronbach’s alpha estimates for the verification of the constructs and item reliability, supported by measurement model estimates (Shammout, 2007). To achieve this, we subjected the constructs of personal and altruistic environmental motivations, corporate responsibility motivations, and economic and financial motivations to construct assessment. In measuring the reliability, we found that a recommended threshold of between 0.50 and 0.60 is acceptable (Hair et al., 2006; Shammout, 2007). As summarized in Exhibit 4, the statistics indicate that the three constructs (PAEM, CCRM, and EFM) show evidence of internal consistency and, therefore, satisfy
the construct and item reliability criteria. The Cronbach’s alpha coefficient ranges from 0.547 to 0.637, while the average extracted variance varies from 0.61 to 0.66. In all, more than 50% of the variance of the constructs is explained. Moreover, the goodness-of-fit indices as shown in Exhibit 6 demonstrate construct validity. Furthermore, the three constructs exceeded the suggested threshold of 0.50 of the variance extracted. Thus, the reliability and variance estimates indicate that all the specified indicators are adequate in their measurement of the constructs.

In our opinion and as supported by various authorities the fit statistics for the model, validation as shown in Exhibit 6 indicates a reasonable goodness-of-fit model. The results showed that the model is validated and achieved all the required fit indices within the acceptable thresholds. The chi square is significant ($X^2 = 269.894$, $df = 351$, $GFI = 0.910$, $AGFI = 0.962$, $NFI = 0.938$, $CFI = 0.964$, $RMSEA = 0.692$, $CMIN = \frac{X^2}{df} = 3.214$, and $p$-value = .000 (Chau and Hu, 2001; Hair et al., 2006; Schreiber et al., 2006).

### Structural Aspect of the Model

We use the SEM to determine or predict the level of causal effect of available green skills (AGS–F2) and monetary green tax incentives (MGTI–F3) on personal and altruistic environmental motivation (PAEM), corporate conscience responsibility motivation (CCRM), and economic and financial motivation (EFM). We aggregated the following factors (PAEM, CCRM, and EFM) as F1. Hypothesis 1: F1 (PAEM, CCRM, and EFM) is significantly dependent on F2 (AGS). Hypothesis 2: F1 (PAEM, CCRM, and EFM) is significantly dependent on F3 (MGTI). To further reduce complexity, we also aggregated the variables measuring a particular factor into one factor. For example, the four variables measuring personal altruistic environmental motivations—enhanced energy efficiency and CO$_2$ reduction, improved water efficiency, thermal comfort and quality acoustic environment, and reduction of solid waste and minimize site impact—were aggregated to PAEM. In the same way, we aggregated the four variables determining corporate conscience responsibility motivations—user satisfaction and more control over the environment, minimization of strain on local infrastructure, reduction in absenteeism and escalation of creativity, and higher morale and lower workforce turnover—to CCRM and so on. It was convenient for us to perform the aggregation because all the aggregated variables had been validated in terms of validity and reliability. However, a few items of available green skills (AGS–F2) loaded insignificantly or have higher modification indices.
Exhibit 7 | Structural Model of Demand Factors Affecting Green Commercial Property Investment

Exhibit 8 | Structural Equation Modeling (Testing Hypotheses Using Standardized Estimates)

<table>
<thead>
<tr>
<th>Hypothesized Path</th>
<th>Standardized Estimates</th>
<th>Std. Error</th>
<th>CR (Z-Value)</th>
<th>Supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1: F1 ← F2</td>
<td>0.47</td>
<td>0.030</td>
<td>6.733***</td>
<td>Yes</td>
</tr>
<tr>
<td>H2: F1 ← F3</td>
<td>0.73</td>
<td>0.024</td>
<td>6.535***</td>
<td>Yes</td>
</tr>
</tbody>
</table>

(MI) (AGS1 and AGS2), so we deleted them. This is in response to a more parsimonious fit of the model, as suggested by (Zainudin, 2012). The path diagram in Exhibit 7 illustrates this scenario.

Exhibit 8 displays the results of the hypothesis testing of the structural model. The estimates of standardized coefficient revealed significant influences between F2 and F3 (available green skills and monetary green tax incentives) on F1 (personal altruistic environmental motivations, corporate conscience responsibility motivations, and economic and financial motivations (F2: β = 0.47; z = 6.733, p > 0.05; F3: β = 0.73; z = 6.535, p > 0.05) respectively. The results indicate that the demand factors of green building such as personal and altruistic
Green Tax Incentives and Other Demand Factors

Exhibit 9 | Goodness-of-Fit Statistics for Model of Demand Factors of Green Commercial Property Investment

<table>
<thead>
<tr>
<th>Chi square</th>
<th>DF</th>
<th>GFI</th>
<th>AGFI</th>
<th>NFI</th>
<th>CFI</th>
<th>RMSEA</th>
<th>CMIN</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>162.348</td>
<td>334</td>
<td>0.937</td>
<td>0.995</td>
<td>0.988</td>
<td>0.833</td>
<td>0.689</td>
<td>2.348</td>
<td>0.000</td>
</tr>
</tbody>
</table>

environmental motivations, corporate conscience responsibility motivations, and economic and financial motivations are significantly influenced by available green skills and monetary green tax incentives. As such, they have a direct positive effect on investors’ decisions to demand and invest in green building, thus constituting the major motivating factors for green commercial building investment (Hair et al., 2006).

However, for a hypothesis to be considered fit to the data, we examined the goodness-of-fit indices. We did this in order to assess and evaluate the structural model. Therefore, in the underlying structural equation modeling assumptions, we examined the coefficient parameter estimates, along with overall model fit indices to test Hypotheses 1 and 2. Exhibit 9 shows that the model demonstrated significant goodness-of-fit values that show that the model fits the data adequately. Thus, our model achieved all the required fit indices within the acceptable thresholds.

Discussion

In this study, we tested the casual effects of monetary green tax incentives and green skills in explaining the decision of investors to invest in green commercial building. Specifically, the objectives of the study was achieved as each motivating construct or factor that is particularly linked to green commercial building investment and demand were identified through the SCT theory and literature review. The predictive constructs were validated as motivating factors for green commercial building demand and investment. In the validated model, the three constructs and factors (F1, F2, and F3) were found to be significantly correlated and were within the acceptable threshold. Overall, the result of the validation confirmed the constructs as factors that influence investors’ decisions to invest in green commercial building. The validated constructs were further modeled to determine the casual effects of green skills and monetary green tax incentives on them.

An examination of the estimated standardized coefficients and z-values showed the effect and influence of F2 and F3 (AGS and MGTI) on F1 (PAEM, CCRM, EFM). Specifically, the findings revealed that monetary green tax incentives (MGTI–F3) had a greater influence on factors affecting green commercial building investment. This implies that incentivizing investors through tax credits, loans or grants and subsidies, tax abatement, property tax credits, low capital gains, and/or low stamp duties could woo them to invest in green building. Furthermore,
to improve green building demand and investment, as well as to minimize environmental impact, it is imperative for the government to pay more attention to making green incentives available and attractive to investors. As our results have revealed, attractive incentives would have stronger and positive influences on investors’ decisions to invest in green building. Incentives that create neutral policy that neither increases property taxes nor decreases government property tax revenue are ideal. Through this, investors and homeowners’ may not be discouraged from installing renewable energy systems such as solar (thermal and photovoltaic), wind turbines, and central wood-fired heating systems, etc. Thus, the findings of this study contribute to the paradigm shift that supports incentivizing green building materials and appliances by making it less costly to boost green building demand and investment. This is consistent with Numraktrakul, Ngarmyarn, and Panichpathom’s (2011) view that tax incentives influence individual green building purchase.

Also, the verification of the structural equation modeling supports the conclusion that the application of green skills such as design skills, construction skills, maintenance skills, and procurement skills are major factors that could improve green building investment. Perhaps, this explains why the construct (AGS–F2) exhibited a significant influence among the factors affecting green building investment and as such had strong linear and positive causal relations with green building investment. An important characteristic of green skills in green building investment is its ability to close any existing gap and reduce any current and future extra budgeted cost of maintenance. Thus, investors are now appropriating and considering the expertise and proficiency that ensures construction best practices, which would create a rational ground of expectations and benefits for green building.

For example, as the demand for energy-efficient building is gradually becoming important, developers’ and investors’ understanding of the heating, ventilation, and air conditioning systems, solar thermal and photovoltaic technologies, and the energy efficiency characteristics of materials before investment is essential. This is because as buildings continue to be part of energy-related carbon emissions, buyers are likely to demand high-performance buildings with new construction techniques that will tackle climate change and reduce emissions. Thus, green skills are important factors in green commercial building investment because of the likely multiple effects they may create. For instance, green technology could increase the rental yield of the building while enhancing the economic values of the building. A well-designed and constructed green office space is likely to command a higher price compared to the typical office space (Hand et al., 2013). This is also consistent with Numraktrakul, Ngarmyarn, and Panichpathom (2011) contention that with enough skills and knowledge of green building, consumers and buyers may be convinced that the purchase decision for green property is not difficult.

**Conclusion**

The objectives of this study were to identify, analyze, and validate the motivating demand factors of green commercial property investment with the aim of
formulating a structural model that can adequately determine the causal effects of monetary green tax incentives and available green skills and knowledge. The findings showed that monetary green tax incentives and available green skills constitute major motivating factors for green commercial property investment. This has some notable implications. It shows that incentives and skills remain a means of sustaining green building investment and demand. Incentivizing investors with effective tax policies and other economic incentives is possible and increasingly likely if governments want to accelerate green building. Furthermore, investigations have shown that adequate construction and demand of green building cannot be easily achieved without tax incentives. As noted earlier, financial incentives such as tax abatements, grants, loans and rebates, fee waivers or reductions, low stamp duties, and low capital gains taxes are efficient ways of reducing the cost of green building construction and improving its demand. This could explain why there was a strong causal relation between monetary green tax incentives and the factors of green building demand.

However, investors and other stakeholders in green building investment in developing countries are still confronted with poor incentives that are not particularly attractive. Indeed, in some cases, tax incentives are non-existent, and governments are reluctant to introduce them. For instance, in developing countries such as Malaysia, green incentives and policies are still beset with notable criticisms. This could be because incentives for getting GBI certification are not strongly market driven and adequately enticing to attract investors, especially in the areas of qualifying persons, qualifying costs, standardization of GBI income incentives, stamp duty exclusion, and absence of clarity. There are cases where green taxes are more pro-supply with little or no process for sensitizing the demand side to enable both investors and suppliers to have a balanced perception of green building investment. This is lopsided because demand complements supply. In addition, there are poor incentives on more efficient and innovative means and the expertise to design and construct green building that can attract and retain high value tenants, reduce environmental footprints, energy use, and operational costs, enhance employee productivity, and promote collaborative and innovative workplaces. Furthermore, what worries investors and developers is what flux of critical factors would best deliver a high-performance green building that can attract buyers and tenants while at the same time maximize core profit values, which this study has identified. As such it is imperative that the government at various levels should review and improve on their green building incentives and policies to encourage investors and further boost green building demand and investment.

Government policies influence green building investment and demand. Government policies, rules, laws, and regulations are instruments used to maintain standards, ensure quality, and regulate market forces. For example, if the minimum standards and requirements such as green certification and rating process are not met or are too rigid and coercive, it could slow green building development and influence the demand pattern. However, favorable policies and regulations could motivate investors to invest in green building. For example, green certifications,
awards, and recognitions in green building could be a significant means of encouraging investors to go green. For instance, green awards like “green flag” could be awarded to individuals or investors who distinguish themselves in green building practices by government or rating bodies like LEED, BREEAM, Green Mark, Green Building Index (GBI), and Green Star. Such actions would increase the interest in the green building investment market. Our study contributes to the literature on the theory of social cognitive theory (SCT) and other related theories. However, the factors and variables used in the model lean greatly on the SCT.

References


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The Impacts of Gasoline Stations on Residential Property Values: A Case Study in Xuancheng, China

Authors  Qinna Zhao, Mengling Liu, and Qi Chen

Abstract  In this paper, we examine the effect of gasoline stations on residential multifamily housing prices in Xuancheng, China. First, a survey examining beliefs and the Not in My Backyard (NIMBY) issues associated with gasoline stations investigated the public attitude toward the impact of gasoline stations. The results show that, although the gasoline stations have adopted advanced safety management, 86% of people believe that they will decrease nearby housing prices. Second, in March and April 2016, a hedonic pricing model was used to measure the impact of gas stations on the sales’ prices of 601 residential units in 22 multifamily neighborhoods that are up to 1,000 meters from the gas stations. The results show that housing prices increase significantly with every additional kilometer from the nearest gasoline station, and the closer to the gasoline station that the house is, the more negative the impact on the housing price. The closest 100-meter band showed almost a 16% reduction in housing price, and the furthest affected band (301–600 meters) was down by almost 9%. The negative effect was not observed at distances beyond 600 meters.

The Not in My Backyard (NIMBY) phenomenon is a situation where one or more members of a community oppose the establishment of an inherently undesirable project (such as a hazardous waste dump or radioactive material storage) too close to their homes, for fear of potential negative consequences. In the early 1970s, many scholars in the United States began to study the negative effect of NIMBY facilities, such as landfills, power plants, prisons, and airports, and achieved useful results. However, in China, although many NIMBY facilities exist, little research has been done on estimating the price effects.

A gasoline station is a type of NIMBY facility; these stations store hazardous substances, such as petroleum, in underground tanks, and they are also power supply stations for cars and other motor vehicles. In recent years, the number of gasoline stations has been increasing quickly, along with the number of motorized vehicles in China. Data show that, by the end of 2013, there were approximately 96,313 gasoline stations in China, with the density being up to 4.48 stations for every hundred kilometers.¹ Over time, the gas station storage tanks may leak, due to corrosion, cracks, defective construction materials, and spills during refilling.
Petroleum pollution from leaking underground storage tanks (LUSTs) contaminates the surrounding soil and local groundwater aquifers and damages the associated watershed and ecological systems. According to the news report on an industrial information website, in China there has been no authoritative investigation into LUSTs from gas stations. In addition, the Control Standards of Leakage Pollution for Gasoline Filling Stations is still at the opinion stage.

Due to the potential environmental and human health risks, gasoline stations may have negative effects on the surrounding neighborhood. This study, therefore, contributes to the literature in China and adds to the growing body of literature on the externality effect of NIMBY facilities. First, we employed a questionnaire survey of residents to examine the beliefs and the NIMBY issues associated with nearby gasoline stations. Then, we use the hedonic price valuation method to determine the cost of this externality. Hedonic methods attempt to identify the price effect associated with each of the factors that affect price, including proximity to a NIMBY facility. The price impact on nearby property values is then used as a measure of welfare loss resulting from the NIMBY facilities.

This paper is organized as follows: First, we review the academic literature regarding the impact of undesirable facilities on property values. Next, we present the findings of a survey that was conducted to understand residents’ cognition on the influence of nearby gasoline stations, especially the effect on housing prices, together with the results of an interview with gasoline station managers to understand the measures taken by gasoline stations to reduce the NIMBY effects. Then, we describe a residential transaction data set of 601 observations that we utilized. We next present several hedonic pricing models utilizing the neighborhoods within one kilometer of a gasoline station in March and April 2016. Tests were conducted to determine a price effect of gasoline stations on surrounding property values and the extent of this effect. This study can provide government and developers with the information needed to establish some timely compensation measures to manage the NIMBY effect and will help residents to understand the NIMBY effect more rationally and make a more reasonable estimation of the NIMBY effect on property values.

**Literature Review**

Conventional theory, operationalized by hedonic regression (Rosen, 1974), holds that the value of a house is determined by its characteristics, including neighborhood amenities and disamenities. Thus, proximity to an undesirable facility should be reflected by a price that is lower than that of an identical house that is not near such a facility, holding all else constant. Hedonic price models have long been used to evaluate not only the physical attributes of housing units (e.g., square footage, number of bathrooms, and air conditioning) but also the surrounding environment and locational amenities (e.g., local school quality, crime rate, and air quality). Many studies have evaluated the effect of hazardous or undesirable facilities on nearby real estate; such studies include the following: waste sites (Kohlhase, 1991; McCluskey and Rausser, 2001; Ihlanfeldt and Taylor,

Valuation of Gas Stations Externalities Studies

Studies in this literature examine the effects of oil or gas pipelines: whether being close to a pipeline alone affects the sales price of residential properties; the direct effect of a pipeline rupture on the values of residential properties; and the effect of a pipeline rupture on properties that do not experience contamination but are proximate to the affected pipeline.

Robert Simons conducted a series of studies on the effects of pipelines that typically carry petroleum products like gasoline, fuel oil, and natural gas. Simons, Bowen, and Sementelli (1997) found a property value loss of 17% in the case of close proximity (same block or within 300 feet) to LUST sites where the site still had tanks in place. Simons and Sementelli (1997) found that non-contaminated, easement-holding properties not directly contaminated by a petroleum pipeline rupture sustain a loss in value. This reduction, attributed to the expectation that another rupture may occur, indicates a 5.5% loss in sales’ price for single-family homes and a 2% to 3% loss for multifamily units. The research also shows that a price reduction continues for several years after the event. Simons (1999) also conducted case study research on the effects of a long-term pipeline leak on a residential neighborhood in Summit Count, Ohio. The long-term petroleum leak that caused localized groundwater contamination in this rural area was found to decrease residential property values upon resale by more than 25%.

Another pipeline study by Simons, Mikelbank, and Winson-Geideman (2001) considered a pipeline spill along the Patuxent River in Maryland where petroleum on its way to a power plant was released into a river and traveled as far as 10 miles away, both upstream and downstream, on both banks of the river. Both hedonic and predictive regression models were used. Approximately 2,300 home sales were examined. The results showed that there was a statistically significant loss in sales’ price of approximately 10% in the first sales’ year.

Hansen, Benson, and Hagen (2006) used a hedonic price model to estimate the effect of proximity to two major fuel pipelines running parallel through suburban areas in Bellingham, Washington. The results showed that proximity to a pipeline is not statistically significant. Fruit (2008) studied the effects of both the announcement to construct and the 2004 completion of a 62-mile long gas pipeline on the sales’ prices of residential single-family properties in Clackamas and Washington counties in Oregon. The author found no negative effect of the gas pipeline on nearby property values. Neither study found support for the effect of proximity to a pipeline on property values.

Boxall, Chan, and McMillan’s (2005) study, which analyzes the effects of oil and natural gas facilities on rural home values in Alberta, Canada, generated mixed
results. They found that home values up to four kilometers away are, on average, 4% to 8% lower, all else being constant. This effect depends on both health risks and other undesirable features posed by nearby facilities. However, the number of nearby underground gas pipelines does not significantly affect property values; perhaps because they are underground and relatively unobtrusive.

Most of the studies above examine the effect of single-family dwellings, and few studies have focused on the effect of condominiums. Winkler and Gordon (2013) used a hedonic pricing model to study the effect of the Deepwater Horizon oil spill on waterfront condominium sales’ volume in impacted areas in Alabama. The results showed that there was a 50% decline in sales volume in the six months following the spill. Prices declined 7% in the six weeks following the spill and increased 8.8% in the following two months. The impact was not significant after the well was capped. Siegel, Caudill, and Mixon (2013) also studied the same case. They found that the spill resulted in a temporary price decrease of $21–$28 per square foot and that the price effect dissipated after three months.

These studies clearly show that pipeline ruptures, resulting in leaks, spill explosions, and environmental damage, unambiguously lower the value of affected properties in the immediate aftermath of the event. Only a small number of studies have reported that there is no obvious evidence that the presence of a pipeline, whether gas or oil, decreases estimated property values. In these studies, transaction prices were uncorrelated with the distance to a pipeline if there was no recent spillage incident; the studies did not separately either identify or estimate the effect on properties with a pipeline easement. Thus, in this paper, we examine the effect of a pipeline easement on the market value of residential properties using a hedonic price model.

**Externality Research Papers in China**

With respect to Chinese property markets, although there are numerous articles on the effect of various factors on real estate prices, the peer-reviewed literature focuses on the valuation of positive effects, such as green space, a subway, views, and schools. The residential housing examined in China typically refers to high-rise condominiums.

Jiang (2006) used a non-parametric regression model to assess the price of housing around West Lake in Hangzhou. The author found that every 1% increase in distance from the house to the lake led to a value decrease of 16.4%. Shi and Zhang (2010) applied the hedonic pricing method (HPM) to analyze the effects of Huangxing Park in Shanghai on the surrounding residential prices, and the results showed that the maximum impact radius was 1.6 kilometers, and the strongest impact location was within 0.3 kilometers. Nie, Wen, and Fan (2010), using the case of Shenzhen Metro Line Phase 1 and the HPM statistical method, quantitatively analyzed the spatial and temporal effect on surrounding property value from 2001 to 2007. The results showed that the transit line had a positive spatial effect on the property value within a radius of 700 meters around stations. The property value increments within the radius of 700 meters and 100 meters were 19.5% and 37.8%, respectively.
However, almost none of the studies on the property market in China address the negative property value effects that may be produced by industrial factories, waste sites, landfills, or incinerators. Further, the only papers are qualitative impact studies, such as whether the contamination had an effect on price. Wang (2005) provided a way to analyze the effect of gasoline stations on surrounding houses by introducing the methods and steps of valuation of real estate, but the author did not analyze actual cases. Wang (2005) studied residential units affected by electromagnetic fields and collected sales price, second-hand housing price, and rental price data to make a comparison with Beijing housing price changes over the same period. The results showed that these facilities can affect the long-term sales’ prices through stagnation, or even decline, and that sales’ prices fluctuated with media reports. Further, pollution controls reduced the negative effects on sales’ prices. However, Zhang only uses a comparison method to value the extent of the effect.

Zheng (2009) estimated the economic value of clean air in Beijing. The results showed that a decrease of 1 microgram per cubic meter in total suspended particulate (TSP) was associated with a 0.93% increase in property values. Chen and Hao (2013) analyzed residents’ negative willingness to pay for waste transfer stations based on a study of spatial difference for 25,200 second-hand house prices in Shanghai. They found that the housing price dropped 3.6% for each kilometer that the houses were closer to the waste transfer station. Zeng, Chen, Miao, and Liu (2014) explored the impacts of contamination on the price of adjacent land based on a study of 515 auction plots of land between January 2001 and May 2013; 14 of the plots were adjacent to the contaminated land. The results showed that contamination resulted in a 31% net loss of land value. The dependent variables included the land area, the land price, the plot ratio, and the land grade.

Zhao, Simons, and Fan (2016) and Zhao, Simons, and Zhong (2016) conducted studies using a hedonic price model. Zhao, Simons, and Fan examined the effects of the Nengda municipal incineration plant in Hangzhou on residential property values. A hedonic pricing model was employed to examine the sales of more than 500 residential condominium units in more than 20 multifamily buildings within ten kilometers of the incineration plants over a one-year-period, 2014. The results showed that proximate properties showed decreases of up to 25.9% in their initial listing prices, declining monotonically until the effect was not identified at three kilometers from the incinerator. Zhao, Simons, and Zhong employed hedonic price modeling for 2,200 residential transactions in more than 70 multifamily buildings within ten kilometers of the incineration plants over a one-year period, from 2014 to 2015. The results showed that the neighboring properties showed decreases of up to 25% in the initial listing price, declining until the effect was not identified, at approximately three kilometers from the incinerator. The most consistent losses were approximately 10%, at 1–2 kilometers from the nearest incinerator.

Thus, with respect to negative externalities on residential property values in China, there is a lack of quantitative research on how to value the effect, what kind of research methods should be used, and the measurement of the effect. This paper addresses these shortcomings for gasoline stations, one kind of NIMBY facility in Xuancheng, Anhui province, China.
Exhibit 1 | The Distance between the Residential Area and the Gasoline Station

<table>
<thead>
<tr>
<th>Distance to Gasoline Station</th>
<th>Neighborhoods</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–300 meters</td>
<td>JZXC, JLXC, MYXC, MJH, MJHY, MXY, KQFJ</td>
</tr>
<tr>
<td>301–600 meters</td>
<td>CDXC, XCJH, ECHY, JBHY, XCBZ</td>
</tr>
<tr>
<td>601–900 meters</td>
<td>MDXC, BL, JTSZ, DFYY, XJJJ</td>
</tr>
<tr>
<td>&gt;901 meters</td>
<td>ZRC, MZSC, SJHY, WLJY, YLW</td>
</tr>
</tbody>
</table>

Study Area

Xuancheng is a national demonstration zone undergoing industrial refurbishment and it is located in southeast Anhui province. The south and southeast regions are in the Tianmu Mountain range, while the southwest and west regions are parts of the Mt. Huangshan and the Mt. Jiuhua ranges, respectively. Xuancheng consists of Xuanzhou District, Ningguo City, and five counties: Langxi, Guangde, Jixi, Jingxian, and Jingde, having an area of 12,340 square kilometers and a population of 2.79 million at the end of 2015.

In this paper, the study area mainly refers to Xuanzhou District. The total area of Xuanzhou District is 2,533 square kilometers, and it has a total population of 868,000. At the end of 2014, the number of private motorized vehicles was 173,609, and there were almost 50 gasoline stations. Exhibit 1 shows the location of nearby residential neighborhoods, while Exhibit 2 shows the locations of gasoline stations in Xuanzhou District.

Attitude of Residents to Gasoline Stations and their Safe Management

Our investigation consisted of two phases. The first phase was an interview of gasoline station managers conducted in Xuanzhou District in April and May 2016. We randomly interviewed managers of two gasoline stations according to the interview outline. The second phase was a questionnaire survey. The survey respondents were people who lived within 1 kilometer of gasoline stations; only 126 agreed to participate in the survey. The survey was conducted in April and May 2016. In the investigation, questionnaires were randomly given to residents to answer on site and were then taken back for SPSS analysis of the data.

Best Practice of Gasoline Stations Safety Management

The interviews of gasoline station managers in Xuanzhou District were conducted to understand whether they have adopted any measures to eliminate the effects of NIMBY. The contents and answers of the questionnaire are as follows: The safety management guidance system used in gasoline stations is the most advanced Health Safety and Environment Management System, given that it includes...
quality, safety, production, and environmental protection. The permit effectively ensures that a gasoline station can meet national safety standards. The managers also implemented the safety regulations to control known risk factors, such as explosions, corrosion of underground storage tanks, and other problems, including staff pre-job training. Security managers carry out pre-and post-job safety checks every day and conduct a thorough check once a week; the oil company also
conducts a regular inspection of all gasoline stations. The oil company is greatly concerned with the life and health of the employees. It implements occupational disease prevention measures, including an annual physical examination, to protect the employees and regularly inspects various factors that may damage the gasoline station.

We believe that the gasoline stations are convenient for customers, and offer fueling and shopping options. The gasoline stations have not received any complaints from nearby residents.

**Resident’s Attitude to the Effect of Gasoline Stations on Housing Price**

The purpose of our investigation is to understand both the attitudes of residents who live at different distances from gasoline stations and their perceptions of the impact of a gasoline station on housing prices. We developed a questionnaire, based on the literature, to identify the factors that influence gasoline stations and their effect on the prices of nearby homes. Exhibit 3 provides the survey questions.

The survey includes questions on participant characteristics (gender, age, residential areas); perception of the influencing factors from gasoline station (fire and explosion, noise pollution, atmosphere, soil and water pollution problems); willingness to live near a gasoline station (yes or no); awareness of the impact of gasoline stations on nearby housing prices (positive effect, no effect, and negative effect); the impact of gasoline stations on the prices of nearby homes (5% or less, 6%–10%, 11%–15%, more than 16%).

Ultimately, 126 valid questionnaires were collected from April 28, 2016 to May 6, 2016. The data obtained from the questionnaires and the questionnaire’s
Exhibit 4 | Basic Information of the Survey Respondents (n = 126)

<table>
<thead>
<tr>
<th>Distance</th>
<th>Respondents</th>
<th>Gender</th>
<th>Age</th>
<th>Male</th>
<th>Female</th>
<th>25≤</th>
<th>26–35</th>
<th>36–45</th>
<th>≥46</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–300 meters</td>
<td>34</td>
<td>12</td>
<td>22</td>
<td>2</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>301–600 meters</td>
<td>31</td>
<td>11</td>
<td>20</td>
<td>1</td>
<td>3</td>
<td>7</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>601–900 meters</td>
<td>31</td>
<td>13</td>
<td>18</td>
<td>2</td>
<td>9</td>
<td>10</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;901 meters</td>
<td>30</td>
<td>13</td>
<td>17</td>
<td>6</td>
<td>4</td>
<td>4</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>126</td>
<td>49</td>
<td>77</td>
<td>11</td>
<td>23</td>
<td>28</td>
<td>64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage</td>
<td>100%</td>
<td>39%</td>
<td>61%</td>
<td>9%</td>
<td>18%</td>
<td>22%</td>
<td>51%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Exhibit 5 | The Most Influential Factors of Gasoline Stations to Nearby Residents (n = 126)

<table>
<thead>
<tr>
<th>Distance</th>
<th>Respondents</th>
<th>Noise Pollution</th>
<th>Convenience of Fuel</th>
<th>Oil Smell</th>
<th>Soil and Groundwater Pollution</th>
<th>Potential Risk of Explosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–300 meters</td>
<td>34</td>
<td>9</td>
<td>12</td>
<td>6</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>301–600 meters</td>
<td>31</td>
<td>8</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>19</td>
</tr>
<tr>
<td>601–900 meters</td>
<td>31</td>
<td>9</td>
<td>4</td>
<td>7</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>&gt;901 meters</td>
<td>30</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>19</td>
</tr>
<tr>
<td>Total</td>
<td>126</td>
<td>30</td>
<td>21</td>
<td>16</td>
<td>7</td>
<td>61</td>
</tr>
<tr>
<td>Percentage</td>
<td>100%</td>
<td>24%</td>
<td>17%</td>
<td>13%</td>
<td>6%</td>
<td>48%</td>
</tr>
</tbody>
</table>

reliability were assessed using Cronbach’s alpha; the figure obtained was 0.96, indicating that variance in the score is explainable. We adopted a descriptive analysis and a cross analysis, using SPSS software, to study the residents’ attitudes regarding the effects of gasoline stations on housing prices.

Exhibit 4 shows that 39% of the 126 survey respondents were women and 61% were men. Respondents aged less than 25 years old accounted for 9%, of the total, those between 26 and 35 years old accounted for 18%, those between 36 and 45 years old accounted for 22%, and those who were older than age 46 accounted for 51%.

Exhibit 5 shows that, among the many effects of the gasoline station, 48% of respondents believed that gasoline is a dangerous substance that is flammable and can be explosive; thus, they thought that the potential risk of explosion could have a significant impact on nearby house prices. Approximately 24% of respondents believed that vehicle noise pollution has the greatest impact on nearby residents,
while 17% believed that the positive externality of gas stations lies in their convenience, such as their fuel and shopping options.

Exhibit 6 shows that 92% of respondents said that they did not want to live near a gasoline station and 86% thought that a gasoline station would reduce the prices of nearby houses. But when asked to assess the housing prices due to the nearby gasoline station, most said they do not know how much the influence would be. And the percentage of answers for each option was basically the same, with the answer being close to the middle option “6%~10%,” indicating that respondents did not know how great the impact of a gasoline station was on the prices of the surrounding housing.

We found that, although the gasoline stations may adopt advanced management methods to reduce risks, most respondents believed that they exhibit a strong NIMBY effect. Nearly 90% of respondents believed that house prices will decrease due to a nearby gasoline station, but the level of influence is unknown. From the perspective of the oil companies, avoiding the NIMBY effect is the government’s mandatory requirement, and the companies themselves also want to avoid this kind of effect as far as is possible. Thus, in the following section, we adopt the hedonic price model to address the impact of a gasoline station on the values of nearby properties.

Residential Transaction Data Set and Models

A hedonic price model is the standard approach to estimating the effects of externalities on residential property value. Our analysis of residential property sales employed a standard hedonic regression technique (Rosen, 1974; Simons, Robinson, and Lee, 2014). The dependent variable is the sale price, and the independent variables include several housing-related control variables. Vectors of independent factors include housing characteristics (typically for stacked-flat condominium sales), location, neighborhood characteristics, and proximity to a gasoline station, measured in various ways, including the distance rings approach. The model takes the form:

$$HP = \beta_0 + \beta_1 HC + \beta_2 LOC + \beta_3 GS + \varepsilon,$$  \hspace{1cm} (1)

where $HP$ is the initial listed sales’ price of each condominium unit sold, in either linear or log form; $\beta_0$ is the model intercept; $HC$ is a vector of housing characteristics, including livable floor area, number of bedrooms, living rooms, and bathrooms, floor, a high-rise dummy, decoration, and age at date of sale; $LOC$ is a vector of proximity variables for distances to CBD (Xuancheng government center) and the nearest shopping mall, school, park, etc.; $GS$ is the distance of the home from the nearest gasoline station, measured either in distance or in 1-kilometer distance rings, as discussed below; and $\varepsilon$ is the error term.

In general, in China data on second-hand (resale) housing transactions are difficult to obtain directly from government offices. Online data of second-hand for-sale
### Exhibit 6 | Residents Attitudes and Perceptions of the Gasoline Stations Effect on House Prices (n = 126)

<table>
<thead>
<tr>
<th>Distance</th>
<th>Respondents</th>
<th>Willingness to Live near Gasoline Station</th>
<th>Effect of Gasoline Station on House Price</th>
<th>Range of Gasoline Station Effect on House Price</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Positive Effect</td>
</tr>
<tr>
<td>0–300 meters</td>
<td>34</td>
<td>5</td>
<td>29</td>
<td>0</td>
</tr>
<tr>
<td>301–600 meters</td>
<td>31</td>
<td>1</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>601–900 meters</td>
<td>31</td>
<td>1</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>&gt;901 meters</td>
<td>30</td>
<td>3</td>
<td>27</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>126</td>
<td>10</td>
<td>116</td>
<td>1</td>
</tr>
<tr>
<td>Percentage</td>
<td>100%</td>
<td>8%</td>
<td>92%</td>
<td>1%</td>
</tr>
</tbody>
</table>
housing listings are generally transparent and available in real time, but actual transaction prices are generally not readily available. The housing resale listings data collected for this paper come from “listings to sell” on http://hz.58.com/.

Among the independent variables, according to research by Wen (2004), the “living level” dummy variable is equal to the sum of five categories, including grocery, supermarket, bank (only including four state-owned banks), post office, and hospital (including hospital, clinic, health service station) within 1,000 meters, and each category is equal to 1 if yes, and 0 otherwise. The “education level” is a dummy variable equal to the sum of four categories, including kindergarten, primary school, middle school, and college in the neighborhood and each category is equal to 1 if yes, and 0 otherwise. “Buslines” is defined as the number of bus lines within 500 meters. The distances for all locational variables, including to the nearest gasoline station, come from an electronic map (http://map.baidu.com). The authenticity and validity of these data are of high quality, and they are generally accepted as being accurate.

We use original list prices for residential condominium transaction data sold in March and April 2016. Second-hand (resale) housing transactions come from published information of the private real estate agency, cleaned of duplicate sales. As mentioned earlier, residential listing prices were obtained at http://hz.58.com/. This yielded 601 transactions.

Exhibit 7 contains descriptive statistics for our housing transaction data set. The typical unit in our data set had 2.81 bedrooms, 1.9 living rooms, 1.26 bathrooms, was on the 6.1th floor, and was 12.52 years old at the time of sale. The typical unit measured 104.18 square meters in size and was listed at ¥ 576,700 prior to sale. The living level was approximately 4 scores, and the education level was approximately 2.6 scores, on average. The distance to CBD was typically 1,562 meters; the distance to a park was 944 meters; and the distance to the nearest gasoline station was 659 meters.

Model Results

Baseline Model

After investigating the broad classes of models (linear, semi-log, and log), and comparing the goodness-of-fit criteria across the three model specifications, a semi-log form offered the best fit as a dependent variable for this study. The results of the first baseline model are shown in Exhibit 8. This model examined 601 condominium sales, and the dependent variable was the list price.

For the baseline model presented in Exhibit 8, the adjusted $R^2$ (reflecting the amount of variation in the dependent variable explained by all the independent variables combined) is 79.3%; in addition, the F-statistic is 167.79 and the Durbin-Watson statistic is 1.72, figures that are also highly satisfactory. The current model has tolerable levels as the variance inflation factor (VIF) for all variables is below 10. Exhibit 8 has a dozen independent variables, as described earlier, and shows the key variable of interest: distance to the gasoline station in meters.
We adopted the stepwise method to run the model. Exhibit 8 shows that there were eight independent variables of 14 variables stepped into the model at the 99% level of confidence; these include the unit area, age at sale, decoration, floor, the high-rise, distance to CBD, and distance to gasoline station. Among the eight variables, the area size, decoration, high-rise, and distance to gasoline station showed a positive effect on house price, while the other variables exhibited a negative effect. In the basic model, the standardized regression coefficient of linear regression was directly related to the hidden price.

The independent variables typically found in a hedonic regression model conformed, for the most part, to expectations (see Exhibit 8). For example, unit area (0.007, or a 0.742% increase in list price for each additional one square meter), living-rooms (0.049, or a 5.02% increase in list price for each additional living-room), decoration level of finish (0.040, or a 4.046% increase in list price for a higher level of decoration on an index scale) were statistically significant at a 99% level of confidence, and high-rise (0.023, or a 2.35% increase in list price for an additional level of high-rise). Age (−.010) and floor (−0.005) were negative and significant at a 99% level of confidence, as expected. We assume that better
### Exhibit 8 | Baseline Regression Model

<table>
<thead>
<tr>
<th>Model</th>
<th>$\beta$</th>
<th>$t$-Stat.</th>
<th>Sig.</th>
<th>Tolerance</th>
<th>VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>3.294</td>
<td>52.304</td>
<td>.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit area</td>
<td>0.007</td>
<td>19.749</td>
<td>.00</td>
<td>.256</td>
<td>3.904</td>
</tr>
<tr>
<td>Age at sale</td>
<td>-0.010</td>
<td>-6.156</td>
<td>.00</td>
<td>.324</td>
<td>3.084</td>
</tr>
<tr>
<td>Bedrooms</td>
<td>-0.006</td>
<td>-0.486</td>
<td>.627</td>
<td>.335</td>
<td>2.983</td>
</tr>
<tr>
<td>Living rooms</td>
<td>0.049</td>
<td>3.300</td>
<td>.001</td>
<td>.682</td>
<td>1.466</td>
</tr>
<tr>
<td>Bathrooms</td>
<td>-0.011</td>
<td>-0.764</td>
<td>.445</td>
<td>.570</td>
<td>1.753</td>
</tr>
<tr>
<td>Decoration</td>
<td>0.040</td>
<td>9.827</td>
<td>.000</td>
<td>.848</td>
<td>1.179</td>
</tr>
<tr>
<td>Floor</td>
<td>-0.005</td>
<td>-3.588</td>
<td>.00</td>
<td>.592</td>
<td>1.689</td>
</tr>
<tr>
<td>High-rise</td>
<td>0.023</td>
<td>3.011</td>
<td>.003</td>
<td>.475</td>
<td>2.105</td>
</tr>
<tr>
<td>Living level</td>
<td>-0.003</td>
<td>-0.350</td>
<td>.726</td>
<td>.210</td>
<td>4.764</td>
</tr>
<tr>
<td>Education level</td>
<td>-0.001</td>
<td>-0.079</td>
<td>.937</td>
<td>.612</td>
<td>1.633</td>
</tr>
<tr>
<td>Distance park</td>
<td>0.000</td>
<td>1.633</td>
<td>.103</td>
<td>.328</td>
<td>3.048</td>
</tr>
<tr>
<td>Buslines</td>
<td>0.003</td>
<td>0.738</td>
<td>.461</td>
<td>.233</td>
<td>4.291</td>
</tr>
<tr>
<td>Distance–CBD</td>
<td>0.000</td>
<td>-7.115</td>
<td>.000</td>
<td>.114</td>
<td>8.759</td>
</tr>
<tr>
<td>Distance–Gasoline station</td>
<td>0.000</td>
<td>9.032</td>
<td>.000</td>
<td>.351</td>
<td>2.852</td>
</tr>
</tbody>
</table>

**Note:**
- The coefficient of Distance to CBD is actually –0.00014; in this case, it retains only three decimal places.
- The coefficient of Distance to gasoline station is actually 0.00018; in this case, it retains only three decimal places.

views from higher floors are not important enough to offset the inconvenience of additional height and greater density.

Housing prices moved significantly down the further the properties were from the Xuancheng CBD, at a rate of 0.014% per meter; and, with respect to distance to the nearest gasoline station, moving further away from the station was associated with an increased list price, at a rate of 0.018% per meter, holding all other variables in constant. This was statistically significant at a 99% level of confidence. Thus, consistent with theory, we conclude that proximity to a gasoline station has a negative effect on property value, but the variable specification (in distance per meter) does not provide information on how far the effect may extend. This is addressed in the next model.

### Distance Rings from Gasoline Station Model

This model can be estimated in two ways. One model is a separate regression for each of the distance rings, while the other is a model estimated over the entire sample, with interaction terms of distance and time period indicators to measure the changing impact of the nearest negative disamenity (Gamble and Dowing,
The results of the distance rings model are shown in Exhibit 9.

This model also examined 601 sales, and the dependent variable was, likewise, the natural log of the list price. The adjusted $R^2$ was 0.81, the F-statistic was 204.728, and the Durbin-Watson statistic was 1.746, all of which are highly satisfactory. The model also had tolerable levels of VIF for all the variables. The same dozen or so independent variables were included, with generally similar results.

The only substantial difference in the models was the key independent variable of interest, distance to the nearest gasoline station, which was expressed in a series of dummy variables of 1,000-meter bands. The results showed that the effect of proximity to any of the gasoline stations on the list prices could be measured, holding all the other variables in the model constant. Within 600 meters of the nearest gasoline station, the coefficient for the corresponding variable showed a negative effect related to the nearest gasoline station: within 100 meters, the coefficient was $-0.181$, or an estimated loss of $16.6\%$ (Halvorsen and Palmquist, 1980); between 101 and 200 meters, the coefficient was $-0.201$, for an estimated loss of $18.2\%$; between 201 and 300 meters, the coefficient was $-0.071$, for an estimated loss of $6.8\%$; between 301 and 600 meters, the coefficient was $-0.094$, for an estimated loss of $8.9\%$; between 601 and 900 meters, the coefficient exhibited a positive effect to the nearest gasoline station, with an estimated increase of $2.8\%$. Thus, we conclude that a gasoline station has a negative effect on property values within 600 meters.

**Spatial Autocorrelation Analysis**

House price data are often spatially correlated. That is, properties with high values are generally located in close proximity to other properties of comparable value, and low value properties are also clustered. Thus, in this study, we are concerned
Impacts of Gasoline Stations

Exhibit 10 | OLS Estimation Results for Spatial Autocorrelation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coeff.</th>
<th>Std. Error</th>
<th>t-Stat.</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>W_InP</td>
<td>3.038</td>
<td>0.153</td>
<td>19.887</td>
<td>0.000</td>
</tr>
<tr>
<td>Unit Area</td>
<td>0.009</td>
<td>0.003</td>
<td>3.543</td>
<td>0.009</td>
</tr>
<tr>
<td>Age at sale</td>
<td>−0.005</td>
<td>0.002</td>
<td>−2.074</td>
<td>0.077</td>
</tr>
<tr>
<td>Bedrooms</td>
<td>0.109</td>
<td>0.072</td>
<td>1.503</td>
<td>0.177</td>
</tr>
<tr>
<td>Living-rooms</td>
<td>0.328</td>
<td>0.090</td>
<td>3.660</td>
<td>0.008</td>
</tr>
<tr>
<td>Bathrooms</td>
<td>−0.382</td>
<td>0.131</td>
<td>−2.912</td>
<td>0.023</td>
</tr>
<tr>
<td>Decoration</td>
<td>0.050</td>
<td>0.022</td>
<td>2.278</td>
<td>0.057</td>
</tr>
<tr>
<td>Floor</td>
<td>−0.005</td>
<td>0.008</td>
<td>−0.621</td>
<td>0.554</td>
</tr>
<tr>
<td>High-rise</td>
<td>−0.007</td>
<td>0.035</td>
<td>−0.205</td>
<td>0.843</td>
</tr>
<tr>
<td>Living-level</td>
<td>−0.024</td>
<td>0.017</td>
<td>−0.141</td>
<td>0.202</td>
</tr>
<tr>
<td>Education-level</td>
<td>−0.002</td>
<td>0.017</td>
<td>−0.136</td>
<td>0.896</td>
</tr>
<tr>
<td>Distance–park</td>
<td>−0.000</td>
<td>0.000</td>
<td>−2.180</td>
<td>0.066</td>
</tr>
<tr>
<td>Buslines</td>
<td>−0.027</td>
<td>0.008</td>
<td>−3.579</td>
<td>0.009</td>
</tr>
<tr>
<td>Distance–CBD*</td>
<td>−0.000</td>
<td>0.000</td>
<td>−4.921</td>
<td>0.002</td>
</tr>
<tr>
<td>Distance–Gasoline station*</td>
<td>0.000</td>
<td>0.000</td>
<td>3.113</td>
<td>0.017</td>
</tr>
</tbody>
</table>

Notes: R-squared = 0.979; Log-likelihood = 57.38; Akaike information criterion = −84.76; Sigma-square = Lagrange Multiplier (lag) = 0.54, P = 0.47; and Lagrange multiplier (error) = 1.22, P = 0.27. *The coefficient of Distance to CBD is actually −0.000166; in this case, it retains only two decimal places. The coefficient of Distance to gasoline station is actually 0.00011; in this case, it retains only two decimal places.

about spatial autocorrelation. However, the residential housing units examined were all high-rise properties; thus, we only had neighborhood centroids, not the location of each transaction. So, we tested for spatial autocorrelation using Moran’s I on these 22 multifamily high rises, and the value of Moran’s I was −0.014, which is close to 0, and indicated less spatial autocorrelation.

The results are shown in Exhibit 10. The results indicate a potentially slight spatial autocorrelation problem. So, we replicated the classical OLS model with 22 neighborhood observations (by using average list price). The adjusted R² was 97.9%, consistent with previous models (79.3%). Of course, with a smaller N, the F-statistic was much lower (69.7), as expected. The parameter estimates on distance to the gas station were about the same, but at 0.011, not 0.014. Both are statistically significant at greater than the 95% level of confidence, so our main results remain unchanged.

For spatial autocorrelation, we compared statistics of the LM-Lag (0.54) and LM-Error (1.22) of the OLS model. As the P-values, they were not significant at the 90% level of confidence; thus, it was not necessary to run the spatial lag and spatial error models. In conclusion, we find that spatial autocorrelation did not affect the main results.
Conclusion

The main aim of this study was to examine the property value impacts of gasoline stations on proximate for-sale residential units in Xuancheng, China. We applied hedonic pricing models, with a total of 601 valid observations, where the dependent variable was the natural log of the original list price in March and April, 2016.

First, a survey of neighborhood residents’ attitudes to nearby gasoline stations and an interview of gasoline station managers showed that almost 90% of the residents believe that a gasoline station has a strong NIMBY effect, the reason being that most of the residents were not fully aware of the safety management measures of these stations and also lacked relevant knowledge of the NIMBY effect. A total of 86% of residents believed that a gasoline station would decrease the prices of nearby houses, but they did not know the extent of such a decrease. Secondly, a hedonic price model was constructed. The results showed that the presence of a gasoline station had a statistically significant negative effect on the value of residential properties within 600 meters, with the closest 100-meter band showing an almost 16% reduction in house prices and house prices in the furthest affected band (301–600 meters) declining by almost 9%.

The results can help real estate developers make comprehensive pricing decisions, both in acquiring development sites and in pricing units for sale, therefore potentially leading to fairer prices and more efficient markets. The models also provide parameter estimates for regional accessibility, traffic conditions, schools, transit, and other proximate factors. For local government, since gasoline stations are a component of local public services, the efficiency of housing markets would be improved if negative externalities attributable to public services can be internalized. Thus, residents could be “made whole” (be free of damage). This research would give city governments the opportunity to create considerably more rational urban planning policies.

Endnotes

3 Ningguo is a county-level city under the jurisdiction of the province, and entrusted by Xuancheng.
4 The number of gasoline stations can be estimated based on the number of motorized vehicles in the city, that is, there are a certain number of vehicles per gas station. And the empirical data indicate approximately 2,500–4,000 vehicles per station. Thus, according to the number of private vehicles and gasoline stations in Xuanzhou District, we can calculate the average level in the District. There are 3,470 vehicles per gas station, which is the average level.
5 In a study on the stability of the list–sales price ratio, Haizhen (2004) analyzed the relation between the list price of a house and the transaction price, based on 270 list–sales price pairs in Hangzhou in 2004. The author found a significant linear relation,
with transaction price = \(-1.196 + 0.930 \times \) listing price, relative to the Chinese housing market. A bivariate plot indicated that the adjusted $R^2$ reflecting the relation between list price and transaction price was 0.983, which was very close. Further, the variance of the residuals of cumulative probabilities of the observations and the expected cumulative probability is normally distributed (Wen, 2004, p. 67). The use of Haizhen’s list–sales price transformation has been used previously in the Chinese real estate literature. For example, Wu, Guo, and Chen (2008) analyzed the impacts of lakes and landscaping on residential house values in Nanjing, and used list price as the dependent variable in a hedonic price model. As with the current case, it was acknowledged that using sales price was theoretically better, but that reliable sales price data were difficult to obtain. The potential magnitude of error in using of the listing data was minimal, as there was a correlation coefficient 0.97 (list–sales) based on a data set of sales from 2006 for Nanjing (the sample size was 49). In China today, the homeowner/sellers’ online list price reflects the anticipated price to the seller in a competitive market with acceptably complete information. Hence, list prices may be more sensitive to market fluctuations, and they are often considered more capable of reflecting the true market value (Pollakowski, 1995). Also, according to a Southwest University of Finance June release of “Chinese household financial survey report of 2012,” the relationship between Chinese families’ self-reported prices and market price is 95%, indicating that self-reported home prices and market prices are closely related. Further, Hao (2014) investigated the level of residential segregation in 2010 in Shanghai and its impacts on neighborhood house prices. List price was used as the dependent variable in this hedonic price model. The author pointed out that ideal second-hand housing prices should be the actual transaction price, but because of China’s real estate transfer tax, with related capital gains tax liability, the reliability of actual sales price may be low, as chattels or other valuable goods or services may be transferred to the seller in a “side deal,” (off the record) to keep the registered sales price low and, thus, minimize, the transfer tax. The author’s conclusion was that residential sales prices tend to be systematically underestimated, consistent with Wu, Guo, and Chen (2008).

6 Percentage log transformation of dummy variables, [exp (0.007) – 1] * 100 = 0.7025%, repeated again below.

7 This variable is a reference category.

8 Percentage log transformation of dummy variables, [exp (-0.091) – 1] * 100 = -16.6%, repeated again below.

References


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In 2014 Spectra Energy (“Spectra”) and DTE Energy announced plans to build a high-pressure natural gas transmission pipeline (called “Nexus”) that would run from the Utica-Marcellus region near eastern Ohio across northern Ohio, into Michigan, and ultimately into Chicago and Ontario, Canada. The stated purpose for building the proposed pipeline is to take anticipated “growing” gas supplies produced from the Appalachian Basin to the “high-demand” markets in Ohio, Michigan, Chicago, and Ontario.\(^1\) Nexus proposes 250 miles of high-pressure, 36-inch diameter pipeline capable of carrying around 1.5 billion cubic feet of natural gas per day.\(^2\)

However, the route proposed by Nexus takes the pipeline through some of Ohio’s fastest growing and most prosperous communities. In particular, the pipeline route promises to disrupt development plans in the City of Green (Summit County). If implemented without revision, the proposed route would render useless substantial portions of prime industrial and commercially zoned land that Green has earmarked for near-term development. Much of this land is next to the Akron-Canton Airport, and is of considerable interest to the business community. The authors were retained by the City of Green to model the fiscal and economic impacts of the pipeline on the local political entities.
Pipelines are needed to efficiently carry natural gas product to market, but a straight line or the most efficient engineering path is not necessarily the most sustainable option. Minimizing impacts to future development is key, and many property-level adjustments could be made to minimize unnecessarily consuming future development land. This would lead to a more sustainable tax base, and allow better use of installed infrastructure. Further, because the time frames on pipeline operating timeframes are so long, a closer look should be paid to fiscal flows for local jurisdictions, so they can plan for financial shortfalls, if any that may occur down the line.

Accordingly, the City of Green has proposed to Nexus an alternate route that accomplishes Nexus’s goals of moving natural gas from Appalachia to Michigan and Ontario. The alternate route, which could be built for about the same cost as Nexus’s plan, bypasses and spares the fast-growing City of Green, instead taking the pipeline through a more rural area. With proper planning, potential negative impacts on future industrial or commercial development could be minimized by using an alternate route in a more rural setting. Although we expect that property value and tax losses, if any, would be minimal for the alternate route, these results are not set forth here.

The route currently proposed through the City of Green would, however, lead to uneconomic remnant parcels, as well as devalued or stranded residential parcels. Avoiding this phenomenon increases sustainability of the community by maximizing developed infrastructure. The proposed route is shown in Exhibit 1. Over the life of the pipeline, this would in turn lead to very substantial losses in property taxes and income tax for the City of Green. In short, while there may be compelling reasons for the pipeline to be built, and while it may be beneficial for portions of Ohio in terms of taxes and construction jobs, the current route leaves the City of Green to suffer disproportionately the losses the pipeline will cause.

Green is located in Summit County, Ohio between Canton and Akron, along U.S. Interstate 77. It was first incorporated as a city in 1992 with a population of 19,179. By 2010, the population of Green had risen to 25,669. During this same period, the population of Ohio grew from 11.03 million to 11.54 million. So while Ohio’s population grew about 4.5% over nearly 20 years, Green’s population grew 34%. Employment in Summit County likewise has been growing faster than in Ohio. From 2013 to 2014, employment in Summit County grew 2.5%, nearly twice the rate of employment in the state (1.3%). In addition, home values in Green ($163,800) are higher than the state of Ohio overall ($130,000). Similarly, Green’s median household income is greater than that of the state ($61,665 to $48,308). Also, according to the City Planning Department, over 100 residential building permits have been issued annually since 2000.

With respect to fiscal indicators, Green has received an “AAA/Stable” for long-term bond ratings. This rating reflects Standard and Poor’s view of the revenue stream from the city income tax (2%) and the ongoing rate of growth in the community. It also reflects Standard and Poor’s judgment that the community’s economy is broad, diverse, and growing. Green has a projected per-capita
Exhibit 1 | City of Green and the Study Area Overview Map

Panel A: Proposed Pipeline Route: Longer View

The highlighted parcels in the City of Green were included in our analysis.

Panel B: Proposed Pipeline Route through the City of Green
effective buying income of 118% of the national average, and the city’s market value grew by 3% the past year to 2.9 billion. It is also home to the Akron-Canton Airport, making the region particularly attractive to new industrial and commercial development. Portions of the proposed route for the Nexus pipeline would affect the airport development zone.

The balance of this case study article presents the pertinent literature, then addresses the methodologies for calculating potential fiscal impacts to residential property (putting losses in a timeframe, calculating foregone property taxes and income taxes), and commercial property (property taxes, income taxes). After the fiscal benefits from the pipeline are set forth, the analysis proceeds with a net fiscal impact summary and conclusions for the City of Green, and overlapping jurisdictions within its boundary.

Literature Review

The literature review covers the effects of linear hazards of which pipelines are a part, as well as pipelines directly, both existing and after explosive events have transpired, on residential property. While there is a fair amount of literature, it turns out reductions in value to existing property is a small part of projected impacts, and the bulk would come from lost opportunity to develop economic remnant (cut-off or stranded parcels), over a long time period. These concepts are introduced in the land residual approach section.

Linear Hazards

We surveyed the literature on linear hazards and pipelines, along with their effects on developable land. Linear hazards include high-voltage overhead transmission lines (HVOTL), railroad tracks, major roads, and pipelines. These linear hazards have essentially similar effects on residential property: typical property value diminution is up to mid-single digits if housing is within a few hundred feet. A meta-analysis encapsulated in the loss calculation tool “Big Matrix” shows that linear hazards are associated with a 4% loss within 100 feet of houses (Simons, 2005, p. 335). The effect of pipelines on non-residential property is covered in the methodology section, and is generally site-specific.

HVOTLs are linear hazards. They have a negative amenity value because they are visually unpleasant and inconsistent with a natural setting. They are also associated with empty land in a right of way that can be used for open space and in some cases temporary uses like gardening. The price-discount effects are expected to be stronger when the occupant can see more transmission line infrastructure, such as homes sold near towers, as opposed to simply near the lines between towers. Furthermore, there is the nuisance of line workers doing maintenance, and the very small possibility of a line meltdown, failure or conflagration. Although no definitive studies have connected the HVOTL issue to health problems, there has been a concern for their negative impact on human health since the 1980s.
Colwell (1990), Delaney and Timmons (1992), Kung and Seagle (1992), Hamilton and Schwann (1995), Des Rossiers (2002), and Wolverton and Bottemiller (2003) have all published in this space. The effects of HVOTLs on property values are very consistent. Residential property within 100–300 feet of a HVOTL sustained losses of 6%–15%, and houses sold 300–600 feet away had losses of 3%–7%. Part of the reduction in property value is likely view-related. Land sales also fall within these general findings, as do results from several different parts of the United States and Canada.

The second example of linear hazards is a railroad, a mode of transportation that is pervasive throughout the U.S. While watching trains go by from a distance may be somewhat entertaining, being up close is a nuisance, and may subject the residents to noise from trains, whistle blowing, the risk of having an animal or child struck by a train, and a very small potential for a calamitous accident. Therefore, there should be a discount associated with close proximity to both railroad tracks and gated crossings (Keller and Rickley, 1993; Rapoza, Rickley, and Raslear, 1998; Bowes and Ihlanfeldt, 2001; Simons and el Jaouhari, 2004; Strand and Vagnes, 2001; Clark, 2005). To summarize, the benefits of railroad transportation in connecting markets are well known, but there is still a trade-off between the need for safety and the need to reduce the level of noise and other nuisances generated by railroad activities. Based on the train studies described above, negative property value effects on residential property are in the single digits for properties within 750 feet of an active rail line. Changes in the publicized volume of traffic can also be capitalized into the market value, as can proximity to gated train crossings.

**Pipeline Literature**

With respect to the residential pipeline literature, there are two types of studies: those for residential property on or near an active pipeline easement and those for (off-easement) properties affected by pipeline ruptures. These effects can be applied formulaically, and represent the expected value of the undesirable potential of a rupture or release event. Reviewing the studies of pipelines on residential property, we conclude that homes on an easement incur a 5% loss, and a 2% loss if within 100–250 feet.

The second type of study demonstrates losses from relatively rare pipeline release events. Property value losses to these residential properties, if there were an event, are expected to be 10%–25% range, but the properties that incur these losses are typically off the easement, in a body of water or creek perpendicular to the pipeline corridor. A summary of the literature is presented in Exhibit 2.
### Exhibit 2 | Highly Relevant Studies on the Effect of Pipelines on House Values

<table>
<thead>
<tr>
<th>Author (Year)</th>
<th>Study Region</th>
<th>Specification of Effect</th>
<th>Main Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simons (1999a)</td>
<td>Fairfax County, MD</td>
<td>The effect of 1993 pipeline rupture in Reston, VA on non-contaminated, easement-burdened residential property in Fairfax County.</td>
<td>(1) Single-family homes (−5.5%)&lt;br&gt;(2) Townhomes (−2.6%)</td>
</tr>
<tr>
<td>Simons (1999b)</td>
<td>Summit County, OH</td>
<td>The effects of a long-term pipeline (petroleum) leak on a residential neighborhood.</td>
<td>The long-term petroleum leak that caused localized groundwater contamination in the rural area was found to decrease residential property values upon resale in excess of 25%.</td>
</tr>
<tr>
<td>Simons, Winson-Geideman, &amp; Mikelbank (2001)</td>
<td>Neighborhoods near Potomac River in MD</td>
<td>Petroleum was released into a river, and traveled as far as 10 miles away both upstream and downstream on both banks of the river.</td>
<td>Significant loss in sales price of affected properties (−10%)</td>
</tr>
<tr>
<td>Hansen, Benson, &amp; Hagen (2006)</td>
<td>Bellingham, WA</td>
<td>The effect of proximity to a major fuel pipeline on housing prices, both before and after a high-profile explosion accident.</td>
<td>No price effect prior to the accident, but a substantial effect after the rupture.&lt;br&gt;(1) 4.6% for a property within 50 feet.&lt;br&gt;(2) 2.3% for a property within 100 feet.</td>
</tr>
<tr>
<td>Wilde, Williamson, &amp; Loos (2014)</td>
<td>Clark County, NV</td>
<td>The effects of proximity to a natural gas pipeline on residential property values. Compared before and after (1) the initial service, (2) a notice on the policy change, and (3) an accident.</td>
<td>(1) No price effects after the initial service.&lt;br&gt;(2) No price effects after a notice increasing the maximum allowable pressure.&lt;br&gt;(3) No price effect after an accident.</td>
</tr>
</tbody>
</table>

Pipelines. It is generally accepted in the academic literature that the impact of environmental contamination or safety issues on undeveloped property values can be addressed by applying the land residual approach. The general idea of this approach is that developable lots affected by contamination must absorb the full price drop (to developed property) from the contamination, as the construction cost of building a house is fixed (Kinzy, 1992; Dowall, 1993). If not, no property would be developed. Thus, a substantial portion of the potential losses relate to uneconomic remnant parcels that result from property being rendered unusable due to the pipeline. The property may be rendered unusable due to loss of access rather than to being contiguous to the pipeline. This approach can readily be applied to platted developable lots.
Since the useful life and corresponding impact period for this pipeline study is 50 years, and since the City of Green is a finite area undergoing substantial growth, the main impacts could occur well into the future (in one, two or three decades if the pipeline path renders developable parcels functionally obsolete, creating economic remnants. This would include denying the property road access or consuming a land buffer (e.g., 250 feet from the centerline of the pipeline easement, or 150 feet from the edge). Otherwise developable sites could become stranded and useless, and any future real estate development, and associated jobs and fiscal impacts, would be foregone.

**Assessment of Potential Effects to Residential Property**

**Data Collection and Assigning Potential Impacts**

We applied principles determined from the literature to each parcel considered in the City of Green. The study area included 7.7 miles in the City of Green, out of the 100+ mile proposed pipeline route. The data sources we employed include:

- City of Green Property Attributes (Summit County Fiscal Office data provided by City of Green);
- Summit County Property Attributes (Summit County Auditor data provided by City of Green);
- Geo-located list of City of Green-identified residential and commercial/industrial development sites (provided by City of Green);
- City of Green Zoning (provided by the City of Green);
- Property tax rate millage table for Green (provided by the City of Green);
- Property tax rate millage table for Summit County (Summit County Auditor).

We examined residential parcels that fell within 150 feet of the proposed pipeline (from the parcel’s nearest lot line). The property value effect of the pipeline was based on different characteristics of each parcel, including whether the proposed easement would cross the parcel, whether the parcel has an existing residential structure, house distance from the pipeline, lot line distance from the pipeline, whether the parcel is part of an allotment or subdivision (demonstration of the intent to be developed), whether the parcel is earmarked by the City of Green as a potential residential development site, acreage of the parcel, how the pipeline would divide the parcel, and the parcel’s zoning. Decision rules based on these characteristics (and their sources in the literature where available) are summarized in Exhibit 3.

**Placing the Potential Impacts in Time**

Once the loss amounts were set, the next step was to determine when the potential loss would occur. Since undeveloped residential properties have the potential to
## Exhibit 3 | Value Reduction Decision Rules for Residential Properties

<table>
<thead>
<tr>
<th>Property Characteristics</th>
<th>Effect (Sources where available)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Directly affected residential parcel with house within 500 feet of pipeline.</td>
<td>5% reduction in property value (Simons, 1999a; Hansen, Benson, &amp; Hagen, 2006)</td>
</tr>
<tr>
<td>B Directly affected residential parcel with house more than 500 feet away.</td>
<td>2% reduction in property value (Simons, 1999a; Hansen, Benson, &amp; Hagen, 2006)</td>
</tr>
<tr>
<td>C Adjacent residential parcel with house within 250 feet of pipeline or lot line within 100 feet of pipeline.</td>
<td>2% reduction in property value (Simons, 1999a; Hansen, Benson, &amp; Hagen, 2006)</td>
</tr>
<tr>
<td>D Directly affected vacant residential parcel with allotment, not rendered unusable by the pipeline.</td>
<td>Land residual approach: reduced by 5% of neighboring occupied properties' average value (Kinzy, 1992; Dowall, 1993)</td>
</tr>
<tr>
<td>E Directly affected vacant residential parcel with allotment that is rendered unusable by the pipeline.</td>
<td>100% reduction in property value</td>
</tr>
<tr>
<td>F Directly affected vacant residential parcel with no allotment that is rendered unusable by the pipeline.</td>
<td>100% reduction in property value</td>
</tr>
<tr>
<td>G Directly affected parcel with other residential structures</td>
<td>5% reduction in property value (Simons, 1999a; Hansen, Benson, &amp; Hagen, 2006)</td>
</tr>
<tr>
<td>H Directly affected parcel containing Green-identified residential development site.</td>
<td>Reduced by the property value of potential subdivided lots that would be lost due to the pipeline (uneconomic remnant) (Axley 8/5/13)</td>
</tr>
<tr>
<td>I Directly affected vacant residential parcel.</td>
<td>Reduced by the property value of potential subdivided lots that would be lost due to the pipeline (uneconomic remnant) (Axley 8/5/13)</td>
</tr>
<tr>
<td>J All other (timber, agricultural, etc.).</td>
<td>No reduction</td>
</tr>
</tbody>
</table>

be substantially affected by the proposed pipeline, they met the test of an “uneconomic remnant,” (e.g., properties that have significantly impaired economic viability). Thus, it is necessary to establish the likely time of development of existing and currently undeveloped residential properties. Hence, a development continuum was created (Exhibit 4) that categorizes each residential property, on a 0–10 scale. Properties given lower numbers on the continuum (developed properties are given a “0”) are more “ready to develop” in their current state than those given higher numbers, which may be decades from development.

Exhibit 4 was vetted by showing it to three Ohio development professionals, one lawyer, one appraiser, and one planner, with a combined 100+ years of real estate experience. They generally concurred that the idea of a continuum was sound, and that given the assignment, that the first few categories (0–3) made sense, especially if viewed as a midpoint of a range of potential time outcomes. For the purpose of a fiscal impact analysis, beyond item 5, there is an implicit assumption that no other land is available in the study area where the desired land use could
**Exhibit 4 | Development Continuum for Residential and Commercial Properties**

<table>
<thead>
<tr>
<th>Ready to Develop</th>
<th>Stage</th>
<th>Description</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>Existing developed; financed, written leases (or sales contracts), company site plan, zoned,</td>
<td>1 year out</td>
</tr>
<tr>
<td></td>
<td></td>
<td>infrastructure investment, platted, strong market demand</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>Written leases (or sales contracts), company site plan, commitment, zoned, infrastructure</td>
<td>2 years out</td>
</tr>
<tr>
<td></td>
<td></td>
<td>investment, platted, strong market demand</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Company site plan, commitment, zoned, infrastructure investment, platted, strong market demand</td>
<td>3 years out</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>Commitment, site master planned, zoned, infrastructure investment, platted, medium-strong</td>
<td>5 years out</td>
</tr>
<tr>
<td></td>
<td></td>
<td>market demand (we recognize that the development period is often shorter; however, conservative</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>estimates are used in this analysis)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>Site master planned, zoned, infrastructure investment, platted, medium market demand</td>
<td>7 years out</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>Zoned, city-planned, infrastructure planning, medium market demand</td>
<td>9 years out</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>Rural zoning, city-planned, infrastructure planning, medium market demand</td>
<td>11 years out</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>Infrastructure planning, low-medium market demand</td>
<td>14 years out</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>Low-medium market demand, raw land</td>
<td>17 years out</td>
</tr>
<tr>
<td>9</td>
<td>9</td>
<td>Low market demand, raw land</td>
<td>20 years out</td>
</tr>
<tr>
<td>Not Ready to</td>
<td>10</td>
<td>Inactive market, raw land</td>
<td>30 years out</td>
</tr>
<tr>
<td>Develop</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: Strong Market: 1-year increments; medium market: 2-year increments; low market: 3-year increments; no market: 10-year increments.*

be diverted to, and that the actual range of outcomes would be more likely to vary from the projected amount. Each stage of the continuum corresponds with an estimate of the number of years out (expressed as the midpoint of a range) from present day, when a property is likely to be developed.

**Loss of Property Value**

As stated above, already-developed residential properties were given continuum values of “0.” In Green, there are 66 such properties. Applying the different decision rules from Exhibit 3, these parcels with existing housing experienced a total current property value reduction of $442,000.

**Potential Loss of Property Taxes**

Using the assigned development continuum value, the change of development status for each residential property was placed somewhere on a 50-year timeline.
After residential property value reductions were calculated for each property, corresponding residential property tax losses were calculated for each year on the 50-year timeline. Property tax losses for each year were then converted to their present value and summed across the timeline. The resulting value represents the total property tax losses from residential properties that would be affected by the pipeline. We also calculated tax rates for the three regions, and the inflation and discount rate factors for the present value analysis.

The present value of the projected property tax losses for residential properties affected by the Nexus pipeline in Green total $18,320,184 over the 50-year timeline. Green Local School District would see the largest reduction ($12,260,891), followed by Summit County ($3,674,262) and Green City ($697,772), with other jurisdictions splitting the remaining PV loss of $1.5 million.

The City of Green also has the ability to collect income taxes from its residents. Accordingly, we also took into consideration income taxes collected from households that would have resided on the potential subdivided residential lots scrapped due to the pipeline. To determine the total income taxes not collected from these potential households, the City’s median household income ($61,665) was multiplied by the number of households (66), an income tax rate of 2%, and an inflation factor of 4.2%. This figure was then multiplied by 50% to account for households that would or would not be employed within Green. After being placed on the 50-year development timeline and present valued, total income tax losses from residents for the City of Green for the 50-year period total $2,821,113.

### Assessment of Economic and Fiscal Effects to Commercial and Industrial Properties

**Property Value Loss Methodology**

Property value losses were calculated for commercial and industrial properties affected by the Nexus pipeline in the City of Green using the same methodology as for residential property. In this instance, “property value” is defined as the sum of a parcel’s land value and building value as assigned by the Summit County Auditor. Property value losses for commercial and industrial properties largely stem from a parcel’s usability for a commercial or industrial purpose, and the hindrance that the pipeline will bring to such a site. Like residential properties that have severely impaired economic viability or development potential, these commercial and/or industrial properties can be deemed “uneconomic remnants.” Thus, we observed the manner in which the pipeline’s proposed easement traversed the properties, taking note of the acreage of the portion of the parcel “cut off” by the pipeline or consumed by the pipeline easement itself (within 150 feet of the centerline). Portions of parcels designated as “cut off” were usually located on the rear or back of properties, away from direct road access. These are uneconomic remnants.
The acreage of a parcel’s cut-off portion was multiplied by the agricultural value of the land to establish the property’s land value reduction. A property’s agricultural value is the average value, in dollars per acre, of nearby properties whose land use is defined as agricultural. In this analysis, the agricultural value is set forth as $5,976/acre.

The calculation of a property’s building value reduction involved finding the potential building square footage that would be forgone due to the Nexus pipeline. Standard floor area ratios (FARs) were used to establish the maximum building square footage that could be developed on each commercial and industrial property. If the property contained existing buildings, their square footage was subtracted from the maximum square footage to set forth the property’s potential building expansion. Next, the total building space that would still be able to be constructed considering the proposed pipeline was calculated. This was found by subtracting the acreage cut-off from the property’s total acreage.

The square footage that could still be constructed was subtracted from the property’s potential expansion to establish the potential building square footage that would be lost due to the pipeline. The resulting figure was then multiplied by $50 to calculate the site’s lost building value.

**Loss of Industrial and Commercial Property Value**

A total of 11 commercial and industrial properties affected by the Nexus pipeline were analyzed in the City of Green. Three parcels contained existing buildings that housed industrial or commercial operations while the remaining eight parcels were identified by the City as future commercial and industrial development sites. Three of the future development properties are currently owned by the Akron-Canton Airport Authority. Exhibit 5 displays characteristics of the 11 properties analyzed within Green, and Exhibit 6 shows a map linked to the data.

The total land value lost across the 11 commercial and industrial properties in Green was $449,112. Because the land value losses would be felt immediately after the pipeline construction, the losses were placed at year zero on the 50-year timeline.

Building value losses for commercial and industrial properties were placed on the 50-year timeline based on their designated continuum values. The combined land value losses (beginning at year zero on the timeline) and building value losses (placed on the timeline at years based on continuum value) were summed, resulting in a total property value reduction figure. Land rent losses to the Akron-Canton Airport Authority were considered but not calculated. Exhibit 7 shows the property value losses for structures, which drives the property tax fiscal impact figures calculated later.

**Loss of Industrial and Commercial Property Taxes**

After commercial and industrial property value reductions were calculated for each property, corresponding property tax losses were found for each year on the
## Exhibit 5 | Industrial and Commercial Properties in Green, Ohio Affected by the Proposed Pipeline

<table>
<thead>
<tr>
<th>Map Reference</th>
<th>Parcel</th>
<th>Ownership</th>
<th>Acreage</th>
<th>Acreage Cut Off</th>
<th>Cut Off %</th>
<th>Buildings</th>
<th>Building SF</th>
<th>Continuum Timeframe</th>
<th>Proximate to Airport</th>
<th>Industrial Park</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: Parcels with existing buildings</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2803987</td>
<td>NCT Development Corp (North Canton Transfer)</td>
<td>22.51</td>
<td>6.95</td>
<td>30.9%</td>
<td>1</td>
<td>16,985</td>
<td>2</td>
<td>Yes</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>2802535</td>
<td>Green Vertical Properties LLC (Canton Elevator)</td>
<td>33.23</td>
<td>18.58</td>
<td>55.9%</td>
<td>1</td>
<td>131,360</td>
<td>1</td>
<td>Yes</td>
<td>None</td>
</tr>
<tr>
<td>3</td>
<td>2811552</td>
<td>AKC Development Co (Allen Keith)</td>
<td>16.72</td>
<td>2.12</td>
<td>12.7%</td>
<td>1</td>
<td>30,186</td>
<td>4</td>
<td>Yes</td>
<td>Joan Dr.</td>
</tr>
</tbody>
</table>
### Exhibit 5 | (continued)

**Industrial and Commercial Properties in Green, Ohio Affected by the Proposed Pipeline**

<table>
<thead>
<tr>
<th>Map Reference</th>
<th>Parcel</th>
<th>Ownership</th>
<th>Acreage</th>
<th>Acreage Cut Off</th>
<th>Cut Off %</th>
<th>Buildings</th>
<th>Building SF</th>
<th>Continuum Timeframe</th>
<th>Proximate to Airport</th>
<th>Industrial Park</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel B: Parcels with no existing buildings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2805458</td>
<td>Shaffers RE LLC (Western Green)</td>
<td>11.58</td>
<td>3.48</td>
<td>30.1%</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>No</td>
<td>None</td>
</tr>
<tr>
<td>5</td>
<td>2807388</td>
<td>Dehoff Agency Inc. (Park Place)</td>
<td>98.49</td>
<td>6.90</td>
<td>7.0%</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>Yes</td>
<td>Park Place</td>
</tr>
<tr>
<td>6</td>
<td>2802955</td>
<td>James &amp; Mildred Helms (Helms Land)</td>
<td>20.38</td>
<td>7.93</td>
<td>38.9%</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>Yes</td>
<td>None</td>
</tr>
<tr>
<td>7</td>
<td>2803988</td>
<td>NCT Development Corp (North Canton Transfer)</td>
<td>13.15&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.97</td>
<td>60.6%</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>Yes</td>
<td>None</td>
</tr>
<tr>
<td>8</td>
<td>2801554</td>
<td>NCT Development Corp (North Canton Transfer)</td>
<td>0.88</td>
<td>0</td>
<td>0.0%</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>Yes</td>
<td>None</td>
</tr>
<tr>
<td>9</td>
<td>2814683</td>
<td>Akron/Canton Airport Authority (Airport)</td>
<td>10.47</td>
<td>0.06</td>
<td>0.6%</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>Yes</td>
<td>None</td>
</tr>
<tr>
<td>10</td>
<td>2815961</td>
<td>Akron/Canton Airport Authority (Airport)</td>
<td>17.43</td>
<td>17.43</td>
<td>100.0%</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>Yes</td>
<td>Port Green</td>
</tr>
<tr>
<td>11</td>
<td>2804562</td>
<td>Akron/Canton Airport Authority (Airport)</td>
<td>22.91</td>
<td>3.72</td>
<td>16.2%</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>Yes</td>
<td>Joan Dr.</td>
</tr>
</tbody>
</table>

**Notes:**

<sup>a</sup> Excludes northern portion of property, which would likely not be developed for commercial or industrial use.

<sup>b</sup> Not shown on Exhibit 6 map; parcel is located west of main group.
50-year timeline. These annual property tax losses were then converted to their present value and summed across the timeline. The resulting value represents the total property tax losses from commercial and industrial properties affected by the Nexus pipeline. This process was completed for each of the three regions, using their differing tax rates.

Property tax losses for commercial and industrial properties that would be affected by the Nexus pipeline in Green total $72,960,476 over the 50-year timeline. Exhibit 8 presents a breakdown of the various jurisdictions that would experience the property tax reductions. Green Local School District would see the largest reduction ($48,848,315), followed by Summit County ($14,599,468), and Green City ($2,815,001). In this analysis, we assume that no tax abatements would be given.

**Loss of Income Taxes**

Income tax losses for commercial and industrial properties that would be affected by the Nexus pipeline in the City of Green were calculated by multiplying acreage of land cut off by the pipeline by an estimated 8.9 employees per acre to find the
**Exhibit 7 | Building Value Reduction for Industrial and Commercial Properties in Green, Ohio Affected by the Nexus Pipeline**

<table>
<thead>
<tr>
<th>Map Reference</th>
<th>Parcel</th>
<th>Ownership</th>
<th>Acreage</th>
<th>FAR</th>
<th>Potential Expansion</th>
<th>Acreage Unaffected</th>
<th>Acreage Cut Off</th>
<th>SF Still Able to Build</th>
<th>Lost Building SF</th>
<th>Lost Building Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2803987</td>
<td>NCT Development Corp (North Canton Transfer)</td>
<td>23</td>
<td>0.20</td>
<td>179,122</td>
<td>16</td>
<td>7</td>
<td>118,574</td>
<td>60,548</td>
<td>$(3,027,420)</td>
</tr>
<tr>
<td>2</td>
<td>2802535</td>
<td>Green Vertical Properties LLC (Canton Elevator)</td>
<td>33</td>
<td>0.20</td>
<td>158,140</td>
<td>15</td>
<td>19</td>
<td>0(^a)</td>
<td>158,140</td>
<td>$(7,906,988)</td>
</tr>
<tr>
<td>3</td>
<td>2811552</td>
<td>AKC Development Co (Allen Keith)</td>
<td>17</td>
<td>0.25</td>
<td>151,895</td>
<td>15</td>
<td>2</td>
<td>128,808</td>
<td>23,087</td>
<td>$(1,154,340)</td>
</tr>
<tr>
<td>4</td>
<td>2805458</td>
<td>Shaffers RE LLC (Western Green)</td>
<td>12</td>
<td>0.25</td>
<td>126,106</td>
<td>8</td>
<td>3</td>
<td>88,209</td>
<td>37,897</td>
<td>$(1,894,860)</td>
</tr>
<tr>
<td>5</td>
<td>2807388</td>
<td>Dehoff Agency Inc. (Park Place)</td>
<td>98</td>
<td>0.40</td>
<td>1,716,090</td>
<td>92</td>
<td>7</td>
<td>1,595,864</td>
<td>120,226</td>
<td>$(6,011,280)</td>
</tr>
<tr>
<td>6</td>
<td>2802955</td>
<td>James &amp; Mildred Helms (Helms Land)</td>
<td>20</td>
<td>0.25</td>
<td>221,938</td>
<td>12</td>
<td>8</td>
<td>135,581</td>
<td>86,358</td>
<td>$(4,317,885)</td>
</tr>
<tr>
<td>7</td>
<td>2803988</td>
<td>NCT Development Corp (North Canton Transfer)</td>
<td>13(^b)</td>
<td>0.20</td>
<td>114,563</td>
<td>5</td>
<td>8</td>
<td>45,128</td>
<td>69,435</td>
<td>$(3,471,732)</td>
</tr>
</tbody>
</table>
### Exhibit 7 (continued)
Building Value Reduction for Industrial and Commercial Properties in Green, Ohio Affected by the Nexus Pipeline

<table>
<thead>
<tr>
<th>Map Reference</th>
<th>Parcel</th>
<th>Ownership</th>
<th>Acreage</th>
<th>FAR</th>
<th>Potential Expansion</th>
<th>Acreage Unaffected</th>
<th>Acreage Cut Off</th>
<th>SF Still Able to Build</th>
<th>Lost Building SF</th>
<th>Lost Building Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>2801554</td>
<td>NCT</td>
<td>1</td>
<td>0.20</td>
<td>7,667</td>
<td>1</td>
<td>0</td>
<td>7,667</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>2814683</td>
<td>Akron / Canton Airport Authority (Airport)</td>
<td>10</td>
<td>0.40</td>
<td>182,429</td>
<td>10</td>
<td>0</td>
<td>181,384</td>
<td>1,045</td>
<td>$(52,272)</td>
</tr>
<tr>
<td>10</td>
<td>2815961</td>
<td>Akron / Canton Airport Authority (Airport)</td>
<td>17</td>
<td>0.40</td>
<td>303,700</td>
<td>0</td>
<td>17</td>
<td>303,700</td>
<td>0</td>
<td>$(15,185,016)</td>
</tr>
<tr>
<td>11</td>
<td>2804562</td>
<td>Akron / Canton Airport Authority (Airport)</td>
<td>23</td>
<td>0.40</td>
<td>399,184</td>
<td>19</td>
<td>4</td>
<td>334,367</td>
<td>64,817</td>
<td>$(3,240,864)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>268</td>
<td>3,560,834</td>
<td>193</td>
<td>75</td>
<td>2,635,581</td>
<td>925,253</td>
<td>$(46,262,657)</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

a. The property’s existing building square footage would exceed the site’s FAR for the portion not cut off by the pipeline.

b. Does not include northern portion of property, which would likely not be developed for commercial or industrial use.

c. Nominal.
total employment lost. This figure was then further multiplied by the City’s average wage ($47,303) and adjusted for benefits to get total lost labor income. Finally, an income tax rate of 2% was applied to the total labor income. Annual commercial and industrial income tax losses were placed on the 50-year timeline based on corresponding properties’ assigned continuum values and were summed to reveal total losses of $45,876,069.

Supply chain and other indirect employment relating to the direct jobs mentioned above would also potentially be lost. Similarly, spending in the economy would create additional jobs (induced employment). Just the induced impact on the economy based on the lost jobs would amount to a loss of 12 additional jobs in the city annually. Looking at the effects on the economy of the City of Green from 2017 to 2030, the lost induced labor income would likely amount to more than $7 million, accompanied by a loss of production with an output worth about $21.4 million. However neither the indirect or the induced employment losses, and lost income taxes therefrom, have been included in the total income tax losses set forth above.

Construction jobs created from the building of potential commercial and industrial (as well as residential) structures, and the corresponding income tax generated, were also considered in the calculation of Green’s total income tax losses. Construction labor costs were assumed to be 42% of total building value (for commercial and industrial properties) and property value (for residential properties). Like the other income tax calculations, the tax rate was set at 2%. Residential construction job income tax losses for Green were $130,041 over the 50-year timeline and commercial and industrial construction job income tax losses were $413,847. At peak buildout, an estimated 670 jobs would be affected. Added to the future households’ income tax, the present value of the City’s total of income tax losses comes to $49,241,070.
Potential Beneficial Fiscal Impacts from the Nexus Pipeline

Pipelines also pay property taxes, so to some extent losses from property devaluation and lost development will be offset by gains in pipeline ad valorem taxes.\(^{23}\) Property taxes for pipelines are based upon an allocation of the total cost of building the pipeline through the taxing jurisdiction. In Ohio, the average personal property tax for utilities is approximately 6% of the value of the assessed property.\(^{24}\)

The property tax base of public utilities like interstate pipelines consists of all tangible personal property owned and located in Ohio on December 31 of the preceding year. Real property includes land and improvements, while personal property includes all plant and equipment owned by the utility. True value is determined by the capitalized cost less the composite annual allowances, which varies according to the age and expected life of the property.\(^{25}\)

The taxable personal property values of the utilities are apportioned among the various taxing districts in which the property resides. For natural gas transportation companies, taxable value is apportioned according to the cost of all taxable personal property physically located in each taxing district as a proportion of the total cost of all such personal property located in the state.\(^{26}\)

Ad valorem taxes are assessed yearly. However unlike for residential property taxes, the values go down over time due to depreciation. In Ohio, the pipeline depreciation is based on a fixed decline rate until it reaches 15%, after which it remains constant for so long as the pipeline is in use.\(^{27}\)

Taxes are not assessed until after the pipeline is built and the capital costs fixed. However, experts have estimated the tax to be about $235,000 per mile for the Nexus Pipeline the first year.\(^{28}\) Using this estimate, and based on the mileage for the proposed pipeline in the City of Green (7.7 miles), we can estimate the likely tax revenue from the pipeline to the taxing entity. An estimate for 50 years, which includes depreciation at a constant rate until it reaches 15%, indicates that the City of Green would receive a present value (2016 dollars) of $674,450 in tax revenues from construction and operation of the pipeline.\(^{29}\)

Net Fiscal Impacts for the City of Green

The City of Green, of course, only gets a small portion of this and other property taxes paid by those who have real property or utilities with physical assets in the city. Exhibit 9 displays the overall fiscal effects of the proposed Nexus pipeline through the City of Green between 2016 and 2065. Income taxes foregone dominate the fiscal picture. Total property tax reductions and total income tax reductions were summed to create a total tax loss figure of $52,753,843. Subtracting the revenue that the City would receive from the pipeline leaves a total (net present value) negative impact of $52,079,393.\(^{30}\) As a comparison, the annual expenditure budget for the City of Green in 2015 was $32.0 million.\(^{31}\)
**Exhibit 9 |** City of Green Fiscal Summary, 2016–2065 (Present Value, 2016$)

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Property Tax Reduction</td>
<td>$(697,772)</td>
</tr>
<tr>
<td>Industrial Property Tax Reduction</td>
<td>$(2,347,279)</td>
</tr>
<tr>
<td>Commercial Property Tax Reduction</td>
<td>$(467,722)</td>
</tr>
<tr>
<td>Future Households Income Tax Reduction</td>
<td>$(2,821,113)</td>
</tr>
<tr>
<td>Commercial and Industrial Income Tax Reduction</td>
<td>$(45,876,069)</td>
</tr>
<tr>
<td>Construction Job Income Tax Reduction</td>
<td>$(543,888)</td>
</tr>
<tr>
<td>Total Tax Reduction</td>
<td>$(52,753,843)</td>
</tr>
<tr>
<td>Revenue from Pipeline</td>
<td>$674,450</td>
</tr>
<tr>
<td>Net Total Impact</td>
<td>$(52,079,393)</td>
</tr>
</tbody>
</table>

Thus, the present value of the foregone tax revenues ($52.1 million) represents a substantial amount. Exhibit 10 shows the same data in a line graph, using nominal dollars.

The picture illustrates the negative cumulative effect of a long hold period. City revenue losses are dominated by the income tax. Because the city receives such a small portion of the property tax, the pipeline revenue is net positive only for the first year or so, then gradually diminishes, until after about five years potential losses to tax collections vastly outweigh the negligible benefits from a largely depreciated pipeline.
Moving to the effect of all taxing jurisdictions within the City, Exhibit 11 provides an overview of the proposed pipeline’s net fiscal impact on all taxing jurisdictions within Green.\(^3\) The fiscal effects of the pipeline on all taxing jurisdictions within Green include overall losses of $122,813,868, summing property and income tax losses and subtracting pipeline revenue of $17.7 million.

Exhibit 12 similarly shows a nominal comparison of annual tax losses and pipeline revenue for all taxing jurisdictions within the City between 2016 and 2065. These
potential revenue losses are much more dependent on property taxes. The graph exhibits a similar pattern, although the scale is much larger, to reflect losses primarily from the local school district. These figures show that despite early revenue gains from the Nexus pipeline, tax losses (including property and income) equal these gains after about 5–7 years. After the pipeline is mostly depreciated in 15 years, potential revenue loss vastly outweighs short-term gains for the balance of the study period.

With respect to where along the pipeline expected losses would occur, Exhibit 13 shows the spatial distribution of present value of gross fiscal losses along the pipeline segment running through the city of Green. It can be seen that a large portion of the expected losses occur close to the Akron-Canton Airport.

**Conclusion**

In 2015, Nexus announced plans to build 250 miles of high-pressure natural gas transmission pipeline that would run from northeastern Ohio into Michigan, and ultimately Ontario, Canada. The pipeline route proposed takes it through one of Ohio’s fastest-growing communities: the City of Green, in Summit County Ohio south of Cleveland. The path proposed by Nexus would cause the City of Green to disproportionately bear the burden of anticipated economic losses and reduction in tax revenue associated with the pipeline. This represents an unsustainable fiscal loss on potential host communities, especially after the fiscal benefits from the pipeline largely are exhausted after about seven years. In other words, the financial benefits from the pipeline are front-loaded, leaving the period of greatest impact without any offsetting fiscal revenue.
In the last 20 years, Green’s population has grown by 34% (to 25,669), compared to 4.5% for Ohio. Green has a projected per capita effective buying income of 118% of the national average, and has received a “AAA/Stable” rating for its long-term bonds, reflecting Standard and Poor’s view that the community’s economy is strong and growing. It is also home to the Akron-Canton Airport, making the region particularly attractive to new industrial and commercial development. The proposed pipeline route would cut through a substantial part of the industrial district proximate to the airport.

If the pipeline were built along Nexus’ proposed path, the City of Green would suffer substantial diminution in property value along the pipeline route. This would in turn lead to a reduction of around $3,500,000 (2016 dollars) in tax revenue for the city, which would not be offset by the ad valorem tax that would likely be collected ($674,450) from the pipeline company for the same 50-year period. Property value diminution relates to both anticipated losses associated with pipeline proximity, and to the creation of uneconomic remnants resulting from the loss of access to a number of commercial, industrial, and residential properties.

The proposed pipeline path would also lead to losses in income taxes for the City of Green. Green collects a 2% income tax from both its residents and from workers in the city. Both would be affected; homes would not be built as a result of the pipeline, and businesses would not be developed. The associated total loss in income taxes collected over 50 years is expected to be substantial. Net loss, after offsetting the taxes received from the pipeline company, for the City of Green would be around $52 million, present value. This number does not include income tax losses generated from indirect or induced employment.

This case study shows that the fiscal and economic impacts of the proposed Nexus pipeline would likely result in large tax losses not only for the City of Green itself, but also for its corresponding taxing jurisdictions. For all taxing jurisdictions within Green, losses are projected to total over $123 million, present value, approximately two-thirds of which would be absorbed by the local school district.

**Endnotes**


2 Ibid.


Using a hypothetical scenario of a developable lot with a land value of $50,000 in a neighborhood where finished homes would sell for approximately $200,000, we can apply the concept of land residual approach to pipeline studies. If we assume that the contamination caused by a pipeline accident reduces property values by 10%, then the contaminated lot and house, once improved, could sell for only $180,000. However, because construction costs are fixed, the lot can only be improved at a cost (including developer’s profit) of $150,000. Thus, the land value must fall from $50,000 to $30,000 to meet the discounted sale price resulting from the pipeline accident. Therefore, the affected land value drops by considerably more than 10% (in this hypothetical situation, by 40%).


According to Nexus, the lifespan for steel pipelines such as that proposed for the Nexus project is “indefinite.” Further, “[t]here are many pipelines in the U.S. and Canada that have operated safely for several decades and should be able to continue operating safely for the foreseeable future.” See: http://www.spectraenergy.com/Safety/Pipeline-SafetyPublic-Awareness/Natural-Gas-Pipeline-FAQs/ Based on this estimate, 50 years was chosen as the lifespan of the Nexus pipeline for this study. Other sources also put the life expectancy for natural gas pipelines at about 50 years. See, for example, “Aging Gas Pipe Danger Lurks Under US Homes.” CBS News, September 14, 2010. Found at: http://www.cbsnews.com/news/aging-gas-pipe-danger-lurks-under-us-homes/.

The present value calculation uses an inflation rate of 4.2%, or that experienced over the past 50 years (1965–2015). The calculation also uses a discount rate of 2.5%, based on a conservative estimate of the City of Green’s bond rate (AAA). See “CPI Inflation Calculator” United States Bureau of Labor Statistics 2015. Found at: http://data.bls.gov/cgi-bin/cpicalc.pl Property tax rates were obtained from the Summit County Auditor, and total just over 2% of market value per year, of which about two-thirds goes to the local school district.

“Green city, Ohio” United States Census Bureau: American FactFinder Community Facts (2010–2014 American Community Survey 5-Year Estimates). Found at: http://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml. Note: This value represents the median household income for the City of Green, which differs from the average wage for jobs located within the city used in other portions of the analysis ($47,303).

This includes commercial and industrial properties that would be directly traversed by the proposed pipeline easement.

In this analysis, we assume that vehicular access over the pipeline’s easement would be limited or prohibited.

Floor area ratios compare a building’s total floor area to the size of the land upon which it is constructed. A floor area ratio of 0.4 was used for properties that would likely see higher-density development, 0.25 for properties that would likely see medium-density development, and 0.2 for properties that would likely see lower-density development.

Based on industry standards.

Based on analysis of commercial and industrial property site maps and photographs.

For example, a five-acre parcel would have industrial land value of $1–2 per square foot. Therefore, at the upper end of the scale, this parcel would be worth approximately $436,000. Assuming a 5% rate of return, annual land rents not collected would
approximate $22,000 for this hypothetical five-acre site, unadjusted for inflation. Thus, the impact is likely to be fairly small. We assume that the land would be leased to industrial tenants at market rates.

These data are based on employment, number of establishments, and wages recorded in the Quarterly Census of Employment and Wages—a government program that publishes a quarterly count of employment and wages reported by employers. These data do not include self-employed, student employment, and a few other categories of employment.

To assess the potential losses in employment, labor income, and output, the 2015 IMPLAN model and data package were used for Summit County, Ohio. The results were scaled back to the share of the City of Green’s economy within the county (about 5.8%). Indirect labor income was not calculated, since it is uncertain as to what the industries would be located in the City of Green.


An ad valorem tax is a tax levy that is apportioned among taxpayers according to the value of each taxpayer’s property. Property taxes are a form of ad valorem taxes. See, for example, C. Comeaux, “Louisiana Property Tax Basics,” Lafayette Parish Assessor. Found at: http://www.lafayetteassessor.com/topicspdfs/louisiana%20property%20tax%20basics%20booklet%203.pdf.


Ibid.

Communication with Ohio Department of Taxation. Fifteen years is the standard depreciation rate normally allowed by the federal government for interstate pipelines, and is used for pipeline revenue calculations in this study. See 2008 CCH Master Depreciation Guide (paragraph 110). Found at: https://books.google.com/books?id=—pLHsdfhEoC&pg=PA100&lpg=PA100&dq=natural+gas+transportation+pipeline+depreciation&source=bl&ots=ZrSmNiKiGiD&sig=3a00GSwgH5gSRL7nqF9q617DF0&hl=en&sa=X&ved=0ahUKEwifvNj-0N7KAhXGVh4KHPhGA-wQ6AEIUzAI#v=onepage&q=natural%20gas%20transportation%20pipeline%20depreciation&f=false. See also: “Seven-year Depreciation for Natural Gas Pipeline.” Accounting Today, January 1, 2004. Notes that the Clajon Gas Company case only changes the depreciation rate for gathering lines. Found at: http://www.accountingtoday.com/prc_issues/2004_1/6612-1.html.


In this analysis, we assumed that utility gross receipt taxes do not affect local jurisdictions. Gross receipt taxes are triggered by an intrastate transaction between the utility and the distribution company or the end user. However, these taxes are paid to the state and not the local jurisdictions.
Although we stand by the reasonableness of our assumptions, we nevertheless conducted a sensitivity analysis of the pipeline’s fiscal effects on the City using an inflation rate of 2.5% (instead of 4.2%) over the 50-year timeline. This analysis revealed total tax losses of $33,290,097 and a net total negative impact of $32,615,647, inclusive of pipeline revenues. Thus, it is evident that there would be very large losses regardless of what inflation factors are assumed.

While it is challenging to directly compare these figures, consider the following illustration. If the average present value amount was spread over all 50 years, it would equal just over $1 million a year. This would represent about 3% of the current annual budget, a substantial impact, emanating from just from this one pipeline siting decision.

Taxing jurisdictions within the City of Green include Summit County, Green LSD, Portage Lakes JVSD, Akron Summit Library, Summit Metro Parks, and the City itself.

References


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The Increasing Value of Green for Residential Real Estate

Authors
Ramya R. Aroul and Mauricio Rodriguez

Abstract
Research has documented a premium for housing with green amenities, on average, over sample periods. Given the increasing efficiency of green features and growing awareness of the environmental concerns in society, we posit that the relation between green amenities and transaction prices is not stationary. We find that premiums associated with green features are growing through time for residential real estate. We explain that this could be driven by a variety of factors. Our results suggest that appraisers should be careful not to make adjustments based on outdated “rules of thumb” pertaining to green characteristics.

Environmental consciousness has grown over time. Harvard’s Center for Green Buildings and Cities finds that support for green buildings is gaining traction. Sanchez, Brown, Webber, and Homan (2008) document substantial savings associated with energy efficiency initiatives. Research indicates that commercial properties with green features are associated with higher rents, as well as higher transaction prices. Das and Wiley (2013) show that the green premiums for commercial properties change with changing market conditions. It is reasonable to expect that premiums for residential properties may also change with changing market conditions.

Green premiums for residential properties have been documented. Aroul and Hansz (2012) report a premium associated with homes with green amenities. Dastrup, Zivin, Costa, and Kahn (2012) find that premiums are paid for homes that have solar panels. These residential studies report the association between green features and transaction prices, on average, over specific time periods. However, evidence is lacking regarding how green premiums might change through time for residential real estate.

In this paper, we extend the literature by examining the temporal variations in green premiums for residential real estate over an eight-year period. There has been increasing concerns regarding the environment, resulting in increasing consumer demand for more environmentally friendlier options. Furthermore, many individuals have started to focus on the environmental impact of their homes. Also, due to an increased awareness of the economic benefits as well as non-financial benefits of energy efficiency, green features have become a more prominent aspect in home purchase decisions. Therefore, we posit that the market’s capitalization of benefits stemming from green features is evolving and is not constant over a long time period. Thus, in this paper we examine whether...
the green premium stays constant over an eight-year sample period and determine if these green premiums change over time.

Consistent with prior work, initially, we report that the properties that are green are sold at a premium of 2.27%, on average, over the eight-year sample period. In addition, we observe that there was a positive impact on transaction prices when green requirements increased during the sample period. Next, we examine the time-varying green premiums in residential transactions. First, we present a year-by-year analysis and observe that green premiums are significant and growing through time. Second, we present results derived from using eight, time-based, green-based variables to examine the temporal differences in valuation of green and find that the green premiums increase monotonically from 2003 to 2009. These results indicate the market may be putting an increasing value on green related amenities. We describe some factors that may be driving these results. For example, increasing premiums could be partially due to improving technologies that provide a relatively higher present value of benefits associated with green features. These results are also consistent with buyers putting increasing value on benefits that greener homes provide to society.

The paper is organized as follows. In the next section, we review the relevant literature. We then describe the study setting and data. Next, we discuss the methods and present our findings. The last section contains the conclusion.

Literature Review

There has been an increasing amount of research in real estate academia on green properties. Much prior work has focused on green initiatives for commercial buildings. Miller, Spivey, and Florance (2008) is one of the first organized studies on green buildings that explore research questions on the benefits of investing in energy savings and environmental design. Fuerst and McAllister (2009, 2011), in a similar endeavor, find consistent results to those by Miller, Spivey, and Florance (2008); all these studies used the same commercial real estate data source from CoStar.

Wiley, Benefield, and Johnson (2010) employ a hedonic estimation of sales price per square foot and find that eco-certified properties transact at a significant price premium when compared to a non-labelled property. Eichholtz, Kok, and Quigley (2013) report that green commercial buildings have higher rents and sell at higher prices. Das and Wiley (2013) document that the green premiums for commercial properties are not stationary, but change with changing market conditions. It is reasonable to expect that green premiums for residential properties may also change with changing market conditions, but this has not been empirically examined for residential real estate.

Studies on residential real estate indicate that green features have a positive impact on residential transaction prices. Aroul and Hansz (2012) examine residential transactions in two Texas cities and report premiums associated with green residential properties, on average, over the time period examined. Kahn and Kok
(2014) report that homes with green labels such as ENERGY STAR, LEED, and Green Point Rated located in California sell for 9% more than homes without labels, on average, over the time period examined. Brounen and Kok (2011) document the factors that influence whether or not a home has an energy rating and also find premiums associated with energy performance certificates in the Netherlands. Aroul and Hansz (2011) document a premium, on average, associated with dual-pane windows. Bloom, Nobe, and Nobe (2011) report that ENERGY STAR qualified homes sold for a premium, on average, in comparison with non-ENERGY STAR qualified homes in Fort Collins, Colorado. Deng, Li, and Quigley (2011) report a 4% premium for green amenities in multifamily residential buildings consisting of private condos and apartments in Singapore. Pivo (2014) documents that green amenities can help forecast lower mortgage default in multifamily rental housing.

Bond (2015) documents that new building codes and legislation have been introduced on a state-by-state basis to improve the energy efficiency of residential properties. Bentley, Glick, and Strong (2015) indicate that Colorado’s real estate appraisers are gradually incorporating sustainable building features in their appraisal projects despite the challenges encountered. Goodwin (2011) documents that green amenities play a significant role when potential home owners make a purchasing decision. Bond (2015) explains that states are adopting increasingly higher efficiency requirements. This suggests that premiums associated with more efficient green amenities could increase through time. Sanderford, McCoy, and Keefe (2018) document that ENERGY STAR adoptions for single-family homes are a function of the local public policies, climate variation, and medium-term energy prices. These findings were based on aggregate proportion of certified adoptions because individual adoption patterns were not available.

To date, the studies on the impact green features have on individual residential transaction prices have examined the average premium throughout the sample periods studied. We extend prior work by examining the time-varying nature of residential green premiums to illuminate the temporal differences on the impact of green feature in residential transaction prices.

**Study Setting**

The Dallas-Fort Worth metropolitan area is considered to be the financial hub of the Southwest, whose growth is attributed to high tech, manufacturing, and service industries. The City of Frisco has a mandatory residential green building program and is one of the fastest growing cities in the United States. The City of Frisco falls within both Collin County and Denton County. Both Collin and Denton counties experienced tremendous population growth in the last decade. Collin County had an approximately 50% increase in population and the highest sustained growth rate in the U.S., at 73.9% since 2000, while Denton County had a sustained growth rate of 61.6% in the same time period (U.S. Census Bureau, 2014).

Frisco is one of the fastest developing cities in the Dallas-Fort Worth metropolitan region. In light of this exploding growth, the city decided to have a mandatory
residential green building program to develop a sustainable community. In May 2001, Frisco became the first city in the U.S. to adopt a mandatory Residential Green Building Program. The efficiency of green amenities improved through time. The mandatory program requirements in Frisco were revised in 2007.4 Hence, it is reasonable to expect that the capitalized benefits buyers could expect from green features were not stationary through time.

Data

The data on property transaction prices were obtained from the North Texas Real Estate Information System’s (NTREIS’s) Multiple Listing Service (MLS) dating from January 2002 through December 2009. The City of Frisco adopted the mandatory Residential Green Building Program in May 2001. Hence the starting year for this study was chosen to be 2002. After careful cleaning of data, the final dataset contained 25,272 data records for Frisco spanning over eight years from 2002 to 2009.

Green Variable

According to the green building ordinance passed on May 2, 2001, all residential plats accepted after May 23, 2001 are required to build to the mandatory green building program standards of the City of Frisco’s Residential Green Building Program. The City of Frisco maintains a list of subdivisions that were platted after 2001. The green variable employed in this study is a dummy variable that gets the value of 1 if the property is deemed to be green and a value of 0 if the residential building is not green. First, we code residential buildings as green if they were in the subdivision that was platted as green. The city updated and improved the Residential Green Building Program and the revised program was put into effect for all homes receiving a building permit on, or after, July 1, 2007. Therefore, all buildings that were built after 2007 are classified as green.6

The City of Frisco’s Residential Green Building Program set forth minimum standards under four major categories: energy efficiency, water conservation, indoor air quality, and water recycling. For instance, under the energy efficiency category, the city mandated that single-family residences should have the Environmental Protection Agency’s ENERGY STAR designation or a score of 83 or less on the Home Energy Rating Systems (HERS) index. With respect to indoor air quality, the city mandated every single-family residence to have a minimum standard of American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard of 62.2 or its amendment. Under the water conservation category, the city required each installed tree to have a portable drip irrigation bag or zoned bubbler system.7

We base our list of green identifiers from the city’s green building program requirements and use them to determine if a home is classified as being green. Extensive key word searches are employed to capture green features and identify houses that were green outside of the mandated program. However, this constitutes only a small portion of the green houses in the sample. We find that the City of
Frisco had 11,094 green homes in the list out of 25,272 homes in the database, which is about 44%.

Methods and Findings

Hedonic pricing models have been applied to study relations between housing attributes like structural characteristics, environmental amenities and disamenities, neighborhood characteristics, time variables, financing options, and locational attributes on the property values. However, the extent to which green amenities are important housing characteristics has been largely overlooked by these models. The few residential studies that use a variable to capture the impact from green features have only used one variable over the entire period studied as described in the literature review section above.

Rosen (1974) argues that individual features and characteristics make up overall asset values. Furthermore, these features and characteristics can be imputed from transaction prices. We use a unique dataset that includes green residential transactions in a traditional hedonic framework to estimate the association between “green” and transaction prices for residential real estate.

Following the traditional housing literature, the dependent variable we employ is the natural log of sales price. Logs of sales prices are regressed against a set of typical control variables along with the green dummy variable as described below. This allows us to estimate how the green features are related to a change in residential property values, holding other characteristics of the properties constant. Exhibit 1 lists the specific variables employed along with their description. Exhibit 2 provides descriptive statistics of the variables.

Similar to the literature, we first examine the impact of “green” on residential transactions, on average, by estimating the following model:

\[ \ln(Sales\ Price) = Constant + \sum \beta_i X_i + \sum \beta_j Y_j + \sum \beta_k Z_k + \beta_g G + e, \]

where \( X_i \) denotes the vector of the physical characteristics of a property such as square footage, age, bedrooms, bathrooms, fireplaces, acres, and garage. In addition, \( X_i \) includes controls for foreclosures. \( Y_j \) denotes a vector of locational attributes such as county and school district. \( Z_k \) denotes a vector of time and seasonality controls such as year of sale, month of sale, and days on market. Our primary variable of interest is the green characteristic variable, which has \( G = 1 \), if house is green, and \( G = 0 \) otherwise. Therefore, the null hypothesis we focus on is whether the coefficient for the green variable \( \beta_g \) is equal to zero.

Consistent with Aroul and Hansz (2012), we find \( \beta_g \) to be positive and significantly associated with the sales prices of residential real estate. We find that
## Exhibit 1 | Variable Descriptions

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LnSales</td>
<td>Natural log of sales price.</td>
</tr>
<tr>
<td>Green</td>
<td>Dummy variable equals 1 if property is green.</td>
</tr>
<tr>
<td>Program</td>
<td>Dummy variable equals 1 if property is green under revised program.</td>
</tr>
<tr>
<td>Green*2002</td>
<td>Dummy variable equals 1 if property is green and sold in 2002.</td>
</tr>
<tr>
<td>Green*2003</td>
<td>Dummy variable equals 1 if property is green and sold in 2003.</td>
</tr>
<tr>
<td>Green*2004</td>
<td>Dummy variable equals 1 if property is green and sold in 2004.</td>
</tr>
<tr>
<td>Green*2005</td>
<td>Dummy variable equals 1 if property is green and sold in 2005.</td>
</tr>
<tr>
<td>Green*2006</td>
<td>Dummy variable equals 1 if property is green and sold in 2006.</td>
</tr>
<tr>
<td>Green*2007</td>
<td>Dummy variable equals 1 if property is green and sold in 2007.</td>
</tr>
<tr>
<td>Green*2008</td>
<td>Dummy variable equals 1 if property is green and sold in 2008.</td>
</tr>
<tr>
<td>Green*2009</td>
<td>Dummy variable equals 1 if property is green and sold in 2009.</td>
</tr>
<tr>
<td>Beds</td>
<td>Number of bedrooms.</td>
</tr>
<tr>
<td>SqFt</td>
<td>Square footage.</td>
</tr>
<tr>
<td>Pool</td>
<td>Dummy variable equals 1 if there is a pool.</td>
</tr>
<tr>
<td>Age</td>
<td>Age of the property.</td>
</tr>
<tr>
<td>DOM</td>
<td>Days on market.</td>
</tr>
<tr>
<td>County</td>
<td>Dummy variable equals 1 if the property is in Collin County.</td>
</tr>
<tr>
<td>Jan</td>
<td>Dummy variable equals 1 if the sale was in January.</td>
</tr>
<tr>
<td>Feb</td>
<td>Dummy variable equals 1 if the sale was in February.</td>
</tr>
<tr>
<td>Mar</td>
<td>Dummy variable equals 1 if the sale was in March.</td>
</tr>
<tr>
<td>Apr</td>
<td>Dummy variable equals 1 if the sale was in April.</td>
</tr>
<tr>
<td>May</td>
<td>Dummy variable equals 1 if the sale was in May.</td>
</tr>
<tr>
<td>Jun</td>
<td>Dummy variable equals 1 if the sale was in June.</td>
</tr>
<tr>
<td>Jul</td>
<td>Dummy variable equals 1 if the sale was in July.</td>
</tr>
<tr>
<td>Aug</td>
<td>Dummy variable equals 1 if the sale was in August.</td>
</tr>
<tr>
<td>Sep</td>
<td>Dummy variable equals 1 if the sale was in September.</td>
</tr>
<tr>
<td>Oct</td>
<td>Dummy variable equals 1 if the sale was in October.</td>
</tr>
<tr>
<td>Nov</td>
<td>Dummy variable equals 1 if the sale was in November.</td>
</tr>
<tr>
<td>Dec</td>
<td>Dummy variable equals 1 if the sale was in December.</td>
</tr>
<tr>
<td>Y2009</td>
<td>Dummy variable equals 1 if the sale was in 2009.</td>
</tr>
<tr>
<td>Y2008</td>
<td>Dummy variable equals 1 if the sale was in 2008.</td>
</tr>
<tr>
<td>Y2007</td>
<td>Dummy variable equals 1 if the sale was in 2007.</td>
</tr>
<tr>
<td>Y2006</td>
<td>Dummy variable equals 1 if the sale was in 2006.</td>
</tr>
<tr>
<td>Y2005</td>
<td>Dummy variable equals 1 if the sale was in 2005.</td>
</tr>
<tr>
<td>Y2004</td>
<td>Dummy variable equals 1 if the sale was in 2004.</td>
</tr>
<tr>
<td>Y2003</td>
<td>Dummy variable equals 1 if the sale was in 2003.</td>
</tr>
<tr>
<td>Y2002</td>
<td>Dummy variable equals 1 if the sale was in 2002.</td>
</tr>
</tbody>
</table>
properties with green features sold for about 2.27% more, as shown in Model 1 in Exhibit 3.

It is reasonable to expect that increased mandatory green requirements could increase the value that buyers place on homes with green features. Therefore, we use an additional control variable to capture the revision of the mandatory program to see if the market attributed more value after the increased green requirements. The Program Revision variable equals one if the house is built after the program was revised in 2007 and zero otherwise. All homes that were built after 2007 were required to have all green features proposed by the city’s green building program. Of course, sales of older homes with no green features as well as sales of other homes with various amounts of green features continued to be sold after 2007.

Model 2 in Exhibit 3 shows that the Program Revision time is significantly related to incremental values. Higher sales prices could be due to the improving efficiencies of green features, as well as increased awareness and attitudes towards green features. Next, we examine whether there are variations across time, apart from the described revision date in mandatory green requirements.

In Exhibit 4, we estimate the same hedonic model as Model 1, but on a year-by-year basis to see if the relation between green and transaction prices for residential real estate changed during our sample period. The coefficient for the green variable for each year is used to ascertain the green premium for each year. Exhibit 4 shows that the coefficient for the green variables were not significant at the start of our sample time period, but became significant and increased in magnitude during the latter years of our sample period. The increasing premiums for green features prior to 2007 could be driven by improving green features or increasing value being placed on green features during those years. The increasing premiums for green features after 2007 are more consistent with increasing value being placed on the improved mandated green features.
### Exhibit 2 | Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
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<td>12.61</td>
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<tr>
<td>Program Revision</td>
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<td>0.49</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Green*2002</td>
<td>0.01</td>
<td>0.05</td>
<td>0</td>
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</tr>
<tr>
<td>Green*2003</td>
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<td>0.13</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Green*2004</td>
<td>0.03</td>
<td>0.14</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Green*2005</td>
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<td>0.17</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Green*2006</td>
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<td>0.16</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Green*2007</td>
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<td>1</td>
</tr>
<tr>
<td>Green*2008</td>
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<td>0.19</td>
<td>0</td>
<td>1</td>
</tr>
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<td>0.13</td>
<td>0</td>
<td>1</td>
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<td>657.65</td>
<td>490</td>
<td>5,095</td>
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<tr>
<td>Pool</td>
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<td>Age</td>
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<td>County</td>
<td>0.88</td>
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<tr>
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<tr>
<td>Feb</td>
<td>0.07</td>
<td>0.25</td>
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<td>1</td>
</tr>
<tr>
<td>Mar</td>
<td>0.09</td>
<td>0.29</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Apr</td>
<td>0.09</td>
<td>0.28</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>May</td>
<td>0.10</td>
<td>0.30</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Jun</td>
<td>0.11</td>
<td>0.31</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Jul</td>
<td>0.09</td>
<td>0.29</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Aug</td>
<td>0.09</td>
<td>0.29</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Sep</td>
<td>0.07</td>
<td>0.26</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Oct</td>
<td>0.08</td>
<td>0.27</td>
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<td>1</td>
</tr>
<tr>
<td>Nov</td>
<td>0.07</td>
<td>0.26</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Dec</td>
<td>0.16</td>
<td>0.25</td>
<td>0</td>
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<td>Y2009</td>
<td>0.06</td>
<td>0.21</td>
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<tr>
<td>Y2008</td>
<td>0.13</td>
<td>0.34</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Y2007</td>
<td>0.15</td>
<td>0.36</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Y2006</td>
<td>0.17</td>
<td>0.38</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Y2005</td>
<td>0.18</td>
<td>0.38</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Y2004</td>
<td>0.15</td>
<td>0.36</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Y2003</td>
<td>0.14</td>
<td>0.34</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Y2002</td>
<td>0.03</td>
<td>0.16</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
We further examine the time-varying green premiums in residential transactions by interacting the green variable with the year dummies. Hence, the next model we estimate is as follows:

$$\text{Ln}(\text{Sales Price}) = \text{Constant} + \sum \beta_i X_i + \sum \beta_j Y_j + \sum \beta_k Z_k + \beta_{gy} G \ast Year + e,$$

(2)

where $G \ast Year$ is the vector of interaction variables obtained by multiplying the green variable by the year dummies. We therefore, generate eight temporal green variables: $\text{Green} \ast 2002$, $\text{Green} \ast 2003$, $\text{Green} \ast 2004$, $\text{Green} \ast 2005$, $\text{Green} \ast 2006$, $\text{Green} \ast 2007$, $\text{Green} \ast 2008$, and $\text{Green} \ast 2009$. The null hypothesis we focus on for these estimates is whether the coefficients for the green temporal interaction variables $\beta_{gy}$ are each equal to zero.

In this analysis, we use the eight time-dependent green variables to examine the temporal differences in the valuation of the green amenities. We test to determine whether the coefficients are stationary and reject the null hypothesis that the coefficients are equal throughout the sample time period. Exhibit 5 presents the temporal results. We find that the green premiums increase monotonically each year from 2003 to 2009. The increased requirements were not in place throughout this time period. Therefore, the observed increases from year-to-year cannot be attributed solely to the increased requirements in 2007. Moreover, the percentage of green homes that were new, which sold each year, went up and down during our sample period. Therefore, the monotonic increases in green premiums that we report are not fully explained by just newer green homes being sold. The increasing green premiums also reflect increasing values placed on older homes that possess green features.
### Exhibit 3 | Green Premiums for Overall Sample (2002–2009)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>0.0227***</td>
<td>0.0226***</td>
</tr>
<tr>
<td></td>
<td>(0.0023)</td>
<td>(0.0023)</td>
</tr>
<tr>
<td>Program Revision</td>
<td>0.0566***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0020)</td>
<td></td>
</tr>
<tr>
<td>Beds</td>
<td>−0.0398***</td>
<td>−0.0399***</td>
</tr>
<tr>
<td></td>
<td>(0.0016)</td>
<td>(0.0016)</td>
</tr>
<tr>
<td>SqFt</td>
<td>0.0003***</td>
<td>0.0003***</td>
</tr>
<tr>
<td></td>
<td>(2.35e-06)</td>
<td>(2.36e-06)</td>
</tr>
<tr>
<td>Pool</td>
<td>0.120***</td>
<td>0.120***</td>
</tr>
<tr>
<td></td>
<td>(0.0032)</td>
<td>(0.0032)</td>
</tr>
<tr>
<td>Age</td>
<td>−0.0006***</td>
<td>−0.0007***</td>
</tr>
<tr>
<td></td>
<td>(9.74e-05)</td>
<td>(0.0001)</td>
</tr>
<tr>
<td>DOM</td>
<td>−5.28e-06</td>
<td>−4.45e-06</td>
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<tr>
<td></td>
<td>(1.24e-05)</td>
<td>(1.24e-05)</td>
</tr>
<tr>
<td>County</td>
<td>−0.0880***</td>
<td>−0.0890***</td>
</tr>
<tr>
<td></td>
<td>(0.0026)</td>
<td>(0.0026)</td>
</tr>
<tr>
<td>FullBath</td>
<td>0.0432***</td>
<td>0.0431***</td>
</tr>
<tr>
<td></td>
<td>(0.0022)</td>
<td>(0.0022)</td>
</tr>
<tr>
<td>HalfBath</td>
<td>0.0053***</td>
<td>0.0054***</td>
</tr>
<tr>
<td></td>
<td>(0.0020)</td>
<td>(0.0020)</td>
</tr>
<tr>
<td>Fireplace</td>
<td>0.0451***</td>
<td>0.0448***</td>
</tr>
<tr>
<td></td>
<td>(0.0025)</td>
<td>(0.0024)</td>
</tr>
<tr>
<td>Fence</td>
<td>−0.0042</td>
<td>−0.0039</td>
</tr>
<tr>
<td></td>
<td>(0.0031)</td>
<td>(0.0030)</td>
</tr>
<tr>
<td>School</td>
<td>0.0479***</td>
<td>0.0481***</td>
</tr>
<tr>
<td></td>
<td>(0.0017)</td>
<td>(0.0017)</td>
</tr>
<tr>
<td>Garage</td>
<td>0.0254***</td>
<td>0.0280***</td>
</tr>
<tr>
<td></td>
<td>(0.0022)</td>
<td>(0.0024)</td>
</tr>
<tr>
<td>Foreclosure</td>
<td>−0.123***</td>
<td>−0.122***</td>
</tr>
<tr>
<td></td>
<td>(0.0029)</td>
<td>(0.0029)</td>
</tr>
<tr>
<td>Constant</td>
<td>11.49***</td>
<td>11.50***</td>
</tr>
<tr>
<td></td>
<td>(0.0078)</td>
<td>(0.0078)</td>
</tr>
<tr>
<td>Seasonality</td>
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<td>Yes</td>
</tr>
<tr>
<td>Year dummies</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>R^2</td>
<td>0.748</td>
<td>0.748</td>
</tr>
</tbody>
</table>

Notes: The coefficients are the results of OLS using residential transaction data from Frisco, Texas. The sample period is from October 2002 to June 2009. Model 1 includes an indicator for green for the overall sample period of 2002–2009. Model 2 includes the same green indicator variable, as well as a variable that captures the Program Revision. Both models include year dummy variables and month dummy variables to control for seasonality. There are 25,272 observations. Standard errors are in parentheses.

* p < .1
** p < .05
*** p < .01
Exhibit 4 | Green Premiums for Year Wise Sub-samples

<table>
<thead>
<tr>
<th>Variables</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>-0.0076</td>
<td>0.0476</td>
<td>0.0127*</td>
<td>0.0138**</td>
<td>0.0187***</td>
<td>0.0202***</td>
<td>0.0219***</td>
<td>0.0291***</td>
</tr>
<tr>
<td></td>
<td>(0.0165)</td>
<td>(0.0066)</td>
<td>(0.0065)</td>
<td>(0.0054)</td>
<td>(0.0055)</td>
<td>(0.0063)</td>
<td>(0.0065)</td>
<td>(0.0091)</td>
</tr>
<tr>
<td>Beds</td>
<td>-0.0073*</td>
<td>-0.0405***</td>
<td>-0.0490***</td>
<td>-0.0466***</td>
<td>-0.0470***</td>
<td>-0.0446***</td>
<td>-0.0394***</td>
<td>-0.0543***</td>
</tr>
<tr>
<td></td>
<td>(0.0040)</td>
<td>(0.0045)</td>
<td>(0.0045)</td>
<td>(0.0040)</td>
<td>(0.0041)</td>
<td>(0.0048)</td>
<td>(0.0050)</td>
<td>(0.0076)</td>
</tr>
<tr>
<td>SqFt</td>
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<td>0.0003***</td>
<td>0.0003***</td>
<td>0.0003***</td>
<td>0.0003***</td>
<td>0.0003***</td>
<td>0.0003***</td>
<td>0.0003***</td>
</tr>
<tr>
<td></td>
<td>(1.34e-05)</td>
<td>(6.12e-06)</td>
<td>(5.96e-06)</td>
<td>(5.52e-06)</td>
<td>(5.79e-06)</td>
<td>(6.50e-06)</td>
<td>(6.71e-06)</td>
<td>(9.86e-06)</td>
</tr>
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<td>Pooldummy</td>
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<td>0.100***</td>
<td>0.118***</td>
<td>0.130***</td>
<td>0.112***</td>
<td>0.137***</td>
<td>0.125***</td>
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</tr>
<tr>
<td></td>
<td>(0.0217)</td>
<td>(0.0082)</td>
<td>(0.0077)</td>
<td>(0.0078)</td>
<td>(0.0076)</td>
<td>(0.00856)</td>
<td>(0.0091)</td>
<td>(0.0132)</td>
</tr>
<tr>
<td>Age</td>
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<td>-0.0010***</td>
<td>-0.0005**</td>
<td>-0.0004*</td>
<td>-0.0007***</td>
<td>-0.0009***</td>
<td>-8.05e-05</td>
<td>-0.0004</td>
</tr>
<tr>
<td></td>
<td>(0.0005)</td>
<td>(0.0002)</td>
<td>(0.0003)</td>
<td>(0.0002)</td>
<td>(0.0002)</td>
<td>(0.0003)</td>
<td>(0.0003)</td>
<td>(0.0005)</td>
</tr>
<tr>
<td>DOM</td>
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<td>-1.13e-06</td>
<td>1.76e-05</td>
<td>1.69e-05</td>
<td>-2.24e-05</td>
<td>-0.001***</td>
<td>1.03e-05</td>
<td>-3.63e-05</td>
</tr>
<tr>
<td></td>
<td>(9.50e-05)</td>
<td>(3.09e-05)</td>
<td>(2.96e-05)</td>
<td>(2.89e-05)</td>
<td>(3.30e-05)</td>
<td>(3.62e-05)</td>
<td>(3.28e-05)</td>
<td>(4.54e-05)</td>
</tr>
<tr>
<td>County</td>
<td>-0.0549***</td>
<td>-0.0478***</td>
<td>-0.0954***</td>
<td>-0.103***</td>
<td>-0.0967***</td>
<td>-0.105***</td>
<td>-0.101***</td>
<td>-0.0893***</td>
</tr>
<tr>
<td></td>
<td>(0.0155)</td>
<td>(0.0065)</td>
<td>(0.0065)</td>
<td>(0.0059)</td>
<td>(0.00647)</td>
<td>(0.0078)</td>
<td>(0.0074)</td>
<td>(0.0101)</td>
</tr>
<tr>
<td>FullBath</td>
<td>0.0599***</td>
<td>0.0239***</td>
<td>0.0390***</td>
<td>0.0412***</td>
<td>0.0481***</td>
<td>0.0563***</td>
<td>0.0351***</td>
<td>0.0288***</td>
</tr>
<tr>
<td></td>
<td>(0.0132)</td>
<td>(0.0056)</td>
<td>(0.0055)</td>
<td>(0.0051)</td>
<td>(0.0053)</td>
<td>(0.0062)</td>
<td>(0.0065)</td>
<td>(0.0099)</td>
</tr>
<tr>
<td>HalfBath</td>
<td>0.0134</td>
<td>-0.0083*</td>
<td>0.0048</td>
<td>-0.0089*</td>
<td>-0.204***</td>
<td>-0.0062</td>
<td>-0.0130**</td>
<td>-0.0112</td>
</tr>
<tr>
<td></td>
<td>(0.0124)</td>
<td>(0.0050)</td>
<td>(0.0050)</td>
<td>(0.0046)</td>
<td>(0.0049)</td>
<td>(0.0055)</td>
<td>(0.0059)</td>
<td>(0.0085)</td>
</tr>
<tr>
<td>Fireplace</td>
<td>-0.0093</td>
<td>0.0121*</td>
<td>0.0412***</td>
<td>0.0725***</td>
<td>0.0512***</td>
<td>0.0440***</td>
<td>0.0518***</td>
<td>0.0338***</td>
</tr>
<tr>
<td></td>
<td>(0.0155)</td>
<td>(0.0067)</td>
<td>(0.0057)</td>
<td>(0.0054)</td>
<td>(0.0059)</td>
<td>(0.0070)</td>
<td>(0.0070)</td>
<td>(0.0108)</td>
</tr>
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</table>
**Exhibit 4** | (continued)
Green Premiums for Year Wise Sub-samples

<table>
<thead>
<tr>
<th>Variables</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fence</td>
<td>0.0288</td>
<td>-0.0246***</td>
<td>-0.0124*</td>
<td>-0.0230***</td>
<td>0.0238***</td>
<td>0.0340***</td>
<td>0.0117</td>
<td>-0.00235</td>
</tr>
<tr>
<td></td>
<td>(0.0198)</td>
<td>(0.0085)</td>
<td>(0.0066)</td>
<td>(0.0066)</td>
<td>(0.0073)</td>
<td>(0.0088)</td>
<td>(0.0095)</td>
<td>(0.0148)</td>
</tr>
<tr>
<td>School</td>
<td>0.0300***</td>
<td>0.0519***</td>
<td>0.0556***</td>
<td>0.0558***</td>
<td>0.0459***</td>
<td>0.0454***</td>
<td>0.0459***</td>
<td>0.0441***</td>
</tr>
<tr>
<td></td>
<td>(0.0106)</td>
<td>(0.0041)</td>
<td>(0.0042)</td>
<td>(0.0038)</td>
<td>(0.0039)</td>
<td>(0.0047)</td>
<td>(0.0049)</td>
<td>(0.0075)</td>
</tr>
<tr>
<td>Garage</td>
<td>-0.0179</td>
<td>-0.0024</td>
<td>0.0038</td>
<td>0.0204***</td>
<td>0.0600***</td>
<td>0.0806***</td>
<td>0.0510***</td>
<td>0.0570***</td>
</tr>
<tr>
<td></td>
<td>(0.0122)</td>
<td>(0.0050)</td>
<td>(0.0051)</td>
<td>(0.0048)</td>
<td>(0.0053)</td>
<td>(0.0073)</td>
<td>(0.0089)</td>
<td>(0.0138)</td>
</tr>
<tr>
<td>Foreclosure</td>
<td>-0.123***</td>
<td>-0.121***</td>
<td>-0.117***</td>
<td>-0.0706***</td>
<td>-0.0814***</td>
<td>-0.118***</td>
<td>-0.130***</td>
<td>-0.154***</td>
</tr>
<tr>
<td></td>
<td>(0.0474)</td>
<td>(0.0108)</td>
<td>(0.0080)</td>
<td>(0.0080)</td>
<td>(0.0073)</td>
<td>(0.0073)</td>
<td>(0.0065)</td>
<td>(0.0094)</td>
</tr>
<tr>
<td>Constant</td>
<td>11.41***</td>
<td>11.42***</td>
<td>11.45***</td>
<td>11.49***</td>
<td>11.43***</td>
<td>11.48***</td>
<td>11.55***</td>
<td>11.59***</td>
</tr>
<tr>
<td></td>
<td>(0.0377)</td>
<td>(0.0178)</td>
<td>(0.0168)</td>
<td>(0.0154)</td>
<td>(0.0166)</td>
<td>(0.0199)</td>
<td>(0.0201)</td>
<td>(0.0286)</td>
</tr>
<tr>
<td>Seasonality</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Year dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Observations</td>
<td>897</td>
<td>3,472</td>
<td>3,773</td>
<td>4,434</td>
<td>4,286</td>
<td>3,755</td>
<td>3,278</td>
<td>1,377</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.743</td>
<td>0.789</td>
<td>0.772</td>
<td>0.772</td>
<td>0.764</td>
<td>0.715</td>
<td>0.720</td>
<td>0.754</td>
</tr>
</tbody>
</table>

Notes: The coefficients reported in the table are the results of OLS using residential transaction data from Frisco, Texas. The sample period ranges from October 2002 to June 2009. In this analysis, we conduct the same analysis in Model 1 of Exhibit 3 but for sub samples. We report nine models (each for each year in the sample period 2002–2009). Model 1 includes an indicator for green using a sub-sample data time period 2002, Model 2 – 2003 sub sample and so on. All models include month dummy variables to control for seasonality. Standard errors are in parentheses.

* $p < .1$

** $p < .05$

*** $p < .01$
## Exhibit 5 | Green Premiums over Time

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green*2002</td>
<td>$-0.0176$ $(0.0065)$</td>
</tr>
<tr>
<td>Green*2003</td>
<td>$0.0037$ $(0.0062)$</td>
</tr>
<tr>
<td>Green*2004</td>
<td>$0.0126^*$ $(0.0071)$</td>
</tr>
<tr>
<td>Green*2005</td>
<td>$0.0139^{**}$ $(0.0050)$</td>
</tr>
<tr>
<td>Green*2006</td>
<td>$0.0181^{***}$ $(0.0049)$</td>
</tr>
<tr>
<td>Green*2007</td>
<td>$0.0223^{***}$ $(0.0157)$</td>
</tr>
<tr>
<td>Green*2008</td>
<td>$0.0229^{***}$ $(0.0052)$</td>
</tr>
<tr>
<td>Green*2009</td>
<td>$0.0234^{***}$ $(0.0054)$</td>
</tr>
<tr>
<td>Beds</td>
<td>$-0.0398^{***}$ $(0.0016)$</td>
</tr>
<tr>
<td>SqFt</td>
<td>$0.0003^{***}$ $(2.35e-06)$</td>
</tr>
<tr>
<td>Pool</td>
<td>$0.120^{***}$ $(0.0032)$</td>
</tr>
<tr>
<td>Age</td>
<td>$-0.0006^{***}$ $(9.75e-05)$</td>
</tr>
<tr>
<td>DOM</td>
<td>$-7.34e-06$ $(1.24e-05)$</td>
</tr>
<tr>
<td>County</td>
<td>$-0.0892^{***}$ $(0.0026)$</td>
</tr>
<tr>
<td>FullBath</td>
<td>$0.0435^{***}$ $(0.0022)$</td>
</tr>
<tr>
<td>HalfBath</td>
<td>$0.0054^{***}$ $(0.0020)$</td>
</tr>
<tr>
<td>Fireplace</td>
<td>$0.0452^{***}$ $(0.0025)$</td>
</tr>
<tr>
<td>Fence</td>
<td>$-0.0036$ $(0.0031)$</td>
</tr>
<tr>
<td>School</td>
<td>$0.0478^{***}$ $(0.0017)$</td>
</tr>
<tr>
<td>Garage</td>
<td>$0.0262^{***}$ $(0.0022)$</td>
</tr>
<tr>
<td>Foreclosure</td>
<td>$-0.123^{***}$ $(0.0029)$</td>
</tr>
</tbody>
</table>
### Exhibit 5 (continued)
Green Premiums over Time

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>11.49***</td>
</tr>
<tr>
<td></td>
<td>(0.0080)</td>
</tr>
<tr>
<td>Seasonality</td>
<td>Yes</td>
</tr>
<tr>
<td>Year dummies</td>
<td>Yes</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.748</td>
</tr>
</tbody>
</table>

Notes: The coefficients reported in the table are the results of OLS using residential transaction data from Frisco, Texas. The sample period ranges from October 2002 to June 2009. Model 3 includes green interaction variables that interacts the green indicator variable with the year variables, for each year during the sample period. The model includes year dummy variables and month dummy variables to control for seasonality. There are 25,272 observations. Standard errors are in parentheses.

* $p < .1$
** $p < .05$
*** $p < .01$

Sanderford, McCoy, and Keefe (2018) indicate that ENERGY STAR adoptions for single-family homes are a function of the local public policies, climate variation, and medium-term energy prices. This study captures the increased green requirements dictated by local policy. The climate was the same in this local area. Hence, climate differences do not drive our results. Energy prices were not constant during the time under study. The price of oil generally increased from 2002 through 2005. The price of oil did not change much in 2006 and then increased again in 2007. Then the price of oil significantly decreased during 2008 before recovering to some extent in 2009. Increased energy prices from 2002 through 2005 and in 2007 could have made green amenities more attractive, but the increased green premiums reported for 2006 and 2008 do not appear to be driven by energy prices given their decrease during those years. However, our results do not fully distinguish between the possibilities that some premiums increased for a set of constant green amenities versus premiums increasing due to improved more efficient green amenities or premiums increasing due to changing attitudes for green amenities. What is clear is that premiums increased for green amenities over our sample period.

Kennedy (1981) demonstrates how to correctly interpret dummy variables in semi-logarithmic equations. We use the Kennedy conversion to convert the computed coefficients into price premium estimates attributable to green features. Exhibits 6 and 7 provide a summary of the changing green premiums across the years in our sample period.
**Exhibit 6** | Green Premiums after Kennedy (1981) Conversion over Time

<table>
<thead>
<tr>
<th>Year</th>
<th>Green Premiums</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>-1.75%</td>
</tr>
<tr>
<td>2003</td>
<td>0.37%</td>
</tr>
<tr>
<td>2004</td>
<td>1.27%</td>
</tr>
<tr>
<td>2005</td>
<td>1.40%</td>
</tr>
<tr>
<td>2006</td>
<td>1.83%</td>
</tr>
<tr>
<td>2007</td>
<td>2.24%</td>
</tr>
<tr>
<td>2008</td>
<td>2.32%</td>
</tr>
<tr>
<td>2009</td>
<td>2.37%</td>
</tr>
</tbody>
</table>

**Exhibit 7** | Green Premiums over Time

The green premiums in 2002 and 2003 are not statistically significant.

**Conclusion**

The literature has reported that homes with green features sell for more, on average over time periods examined, than homes without green features. Due to increases in the efficiencies of green features along with an increased awareness of the economic and other non-financial benefits of energy efficiency, we examine whether the market’s perception on the value of green is evolving and is not constant over a large time period. We extend the literature by examining the temporal variations in green premiums.
We find that premiums associated with green amenities are not stationary. We also find that green premiums increased throughout our eight-year sample period. This is consistent with the notion that home buyers are capitalizing the benefits from increasingly more efficient green amenities. The results are also consistent with buyers becoming more conscious about the benefits green features can provide for society. The State of the Nation’s Housing (2015) report states that 185 out of 715 U.S. cities with populations above 50,000 have green building programs. Out of this group, 124 cities reportedly have programs specifically for residential construction. Most of the programs have been initiated in high population areas in California and Florida. Improvements in technology, combined with the growth of such programs suggests that premiums associated with more efficient green amenities could increase through time.

Theoretically, we should expect variation in green premiums across time and across markets based on different circumstances across time and across locations. All else equal, individuals who live in times of increased energy costs should find green amenities more attractive. The same is true when green amenities provide increased efficiency benefits to owners beyond any increases in the price of the amenities through time. Different green amenities produce different levels of benefits at different cost points. Therefore, we should expect different premiums for different types of green amenities. However, we leave it to future research to examine the benefit from “different shades of green.”

Lower green premiums should be expected in markets with relatively less need for energy efficiencies due to climates that require less heating or air conditioning than more extreme climates. Social attitudes regarding green amenities can also vary across time and markets.

Given the time-varying nature of green premiums that we report, appraisers should not use an old rule of thumb based on a historical average relation green features may have had with transaction prices, but should make adjustments that capture the evolving nature of how green amenities are valued within the market for residential real estate. Appraisers should also be careful not to blindly generalize findings for one market across markets that have different climates or attitudes regarding green amenities.

Lower income individuals can experience higher financial benefits, relative to their incomes, from the savings stemming from green amenities. However, individuals in lower income areas might lack the financial capacity to take advantage of the benefits available from green amenities. Therefore, policymakers should develop programs that help lower income individuals gain access to the growing benefits green amenities can provide.

Endnotes

1 See the State of the Nation’s Housing (2015) report from the Joint Center for Housing Studies of Harvard University.

2 Rose Quint, “Housing Preferences across Generations (Part I),” Eye on Housing (March 7, 2016).
It should be noted that what Frisco previously considered “green building” has been incorporated as minimum code by the International Code Council (ICC). Frisco’s residential green building program was evaluated by a group of home energy raters and the changes that they proposed were incorporated into the adoption of the 2012 International Residential Code. As of January 1, 2014, the minimum standards for energy efficiency—residential green building program in Frisco has been incorporated into its building codes and the separate green building program no longer exists.

This coding by green subdivisions was confirmed using a GIS interactive map provided by the city.

However, not all sales classified as green after 2007 were new homes because there were also sales of existing homes with green features. Age is used as a control variable in the models to help control for differences between newer and older homes.

Aroul and Hansz (2012) provide a description of the mandatory green building standards adopted and revised in Frisco, Texas.

See Sirmons, MacPherson, and Zietz (2005) for a review of the variables typically used in hedonic studies.

The effects of seasonality have been found to be significant in property sales (Goodman, 1992).

When we tested the equality of the yearly green coefficients post regression estimation, the null hypothesis of equality was rejected at the 1% level, indicating that the coefficients are significantly different from one another.

In other words, the total sales of new green homes each year relative to the total sales of green homes (old or new) each year fluctuated during the years examined.

Coefficient after Kennedy conversion = \[\exp(\text{OLS estimator})/\exp(0.5 \times \text{estimated variance of the OLS estimator})\]-1.

This could lead to increasing premiums even for green amenities that do not offer increasing benefits.

We thank the reviewer comments for the term “different shades of green.”

References


Joint Center for Housing Studies of Harvard University. The State of the Nation’s Housing. 2015.


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Mauricio Rodriguez, Texas Christian University, Fort Worth, TX 76109 or m.rodriguez@tcu.edu.
Innovation Districts at the Crossroad of the Entrepreneurial City and the Sustainable City

Authors Dustin Read and Drew Sanderford

Abstract Innovation districts are designed to promote increased interaction between employees and firms in knowledge-intensive industries. They have been praised as both sustainable economic development and sustainable real estate development. Nevertheless, there has been little investigation of how those involved in the planning and development of innovation districts view the role of sustainability. In this paper, we draw on 40 semi-structured interviews with professionals associated with four innovation districts in the U.S. The results provide new insight into how these market participants perceived the components of sustainability in fostering innovation and project success. Economic attributes of sustainability were consistently emphasized as the primary driver of innovation district successes. Further, where social and environmental elements of these districts were acknowledged as factors contributing to project success, professionals tended to frame their roles in economic terms.

Many municipal governments, non-government organizations, and real estate practitioners across the United States have invested their time, capital, and land in the development of innovation districts designed to attract, retain, and grow knowledge-intensive businesses operating within a host of industries (Battaglia and Tremblay, 2010). These projects take on a variety of forms, but are linked by theory and hope that urban areas can be reshaped to facilitate innovation outside the confines of private labs and research facilities (Katz and Wagner, 2014). Innovation districts are therefore an example of an economic development strategy merging the idea of “open innovation,” which emphasizes the benefits companies derive from leveraging the research and development capacity of the external parties with whom they interact (Chesbrough, 2004), with the financial and economic advantages evident from sustainable real estate (Rauterkus and Miller, 2011; Robinson and McAllister, 2015).

Conceptually, innovation districts connect the scholarship of innovation to the theory and practice of economic development, real estate investment, urban design, and land use planning (Read, 2016). As concentrated areas of entrepreneurial activity, they draw together agglomeration and cluster theory with research on tenant mix optimization (Porter, 2000; Rosenthal and Strange, 2001, 2004; Clark,
Huang, and Walsh, 2010). As purposeful facilitators of open innovation or the removal of that process from traditional silos (Chesbrough, 2004), they represent the democratization of spaces between people and firms through thoughtful urban design (Von Hippel, 2004). And as environments intended to catalyze innovation and defend against economic cyclicality, they connect the historical discussion of innovative milieus to the Marshallian industrial cluster (Marshall, 1890; Hall, 1998; Boix and Galleto, 2009).

Importantly for this paper, advocates have also argued that innovation districts can be transformative and sustainable urban places with the potential to address a wide range of social, environmental, and economic opportunities (Katz and Wagner, 2014, p. 2). A growing number of public officials and developers seem to agree and have invested capital and resources in them (Almirall et al., 2016). As a result, an emerging body of evidence is now available to evaluate aspects of these claims (where limited data served as an obstacle). While it is clear that innovation district advocates have justified the projects on sustainability grounds, there is little evidence suggesting how those participating in the planning and development of innovation districts perceive the role of sustainability in creating a competitive advantage and in facilitating innovation. It is here where this paper seeks to make a contribution.

The results of 40 semi-structured interviews, focused around four case studies, are presented below in an effort to unpack how the diverse array of individuals involved in innovation districts view project attributes and stakeholder coalitions. Specifically, the paper addresses the research questions: What do innovation district stakeholders consider as factors of success? Further, what role does sustainability play therein? These questions serve as a starting place for examining the connections between sustainability, real estate, and innovation districts.

The cases examined include Cortex in St. Louis, Missouri, SkySong in Scottsdale, Arizona, Tech Center at Oyster Point in Newport News, Virginia, and Technology Square in Atlanta, Georgia. These cases were chosen because they all have characteristics consistent with modern innovation districts as described in the literature. For example, each came to fruition as a result of a public-private partnership formed between a profit-driven developer, university-affiliated entity, and a local government to accommodate the development of a mixed-use environment fostering collaborative interactions between highly-skilled people and the organizations where they work. These unifying features link the projects for the purposes of empirical analysis despite the fact that they vary in terms of design elements, financing structures, locations, and tenant mix.

Interviewees perceived sustainability as a substantial factor in the shaping of each of the four innovation districts. However, the results consistently illustrate nuances and a somewhat hierarchical prioritization of constituent sustainability components. Interviewees stressed that economic resilience, or the ability to adapt to economic cyclicality and to resist exogenous shocks (Sánchez et al., 2017), was a central strategy or priority in each of the cases. They less frequently spoke of social, energy, and environmental attributes, although they still acknowledged their roles in project success and as part of the demand the professionals observed in their markets; an interesting and important insight for practice.
The remainder of the paper is organized to provide a summary of several strands of literature that connect research related to innovation districts, description of the group of professionals interviewed, and the data those interviews generated, analysis of the interview data, and a discussion of the insights provided by the interviews. As an exploratory qualitative process, the findings have some limitations. Primarily, the discussion questions and the interview process itself are limited by bounded rationality. Additionally, while the general inductive analysis techniques we utilized produce results that may not be easily generalizable, they are certainly transferable to other like type situations (Anderson, 2010). They also provide a useful way to start connecting a research framework to emerging themes in the data (Thomas, 2006). Although these limitations constrain the findings to a degree, they are present in much exploratory research and purposeful sampling and analytical techniques have been used to mitigate their effects. As a first research step, the data derived from the interviews help reveal important first order insights about how those associated with innovation district development and operations perceive these projects.

Literature Review

The term “innovation district” has been used in the urban studies literature for at least two decades (Raco, 1999), but only in recent years have significant efforts been made to operationalize it in a manner supporting critical analysis (Clark, Huang, and Walsh, 2010; Forsyth, 2014; Katz and Wagner, 2014). Similar to Marshallian clusters, innovation districts are described as sub-geographies within cities, usually rather small, exhibiting unusually high concentrations of entrepreneurs, entrepreneurial activity, and innovative firms (Boix and Galleto, 2009). They often include high-density, mixed-use, transit-oriented, pedestrian-friendly, urban design elements producing places and interstitial spaces where highly-skilled people can engage, share, and create (Battaglia and Tremblay, 2010).

As innovation districts are real estate development projects, as well as components of economic development strategies focused on facilitating innovation and growth within knowledge-centered businesses, the literature underpinning their evaluation is broad, connecting elements of research conversations about sustainable real estate, economic development, and agglomeration economics. Innovation and its role in changing the face of both business and place is embedded in each of these three areas. Consequently, the objective of this section of the paper is to provide a summary of these areas of the literature.

Sustainable Real Estate

Innovation districts are designed to be physical spaces where individuals, firms, and innovation can flourish. This goal connects them to a growing conversation within the real estate finance and economics literature on the role sustainability and innovation play in shaping real estate markets. Within this conversation, scholars have examined three broad types of research questions: (1) how to
incorporate sustainability into real estate development and investment decisions; (2) what is the value proposition of sustainability across different asset classes in the real estate market; and (3) what are the roles of sustainability and innovation in the property markets.

Research about the incorporation of sustainability into real estate development and investment processes emerged alongside questions about corporate social responsibility (Kats et al., 2003; Spitzer, Emerson, and Harold, 2007; Pivo and McNamara, 2008) and the triple-bottom-line (Pivo and McNamara, 2005). Reflecting evolving notions of the theory of the firm, agency theory, and issues of stewardship, researchers argued that doing well and doing good (e.g., considering people, profit, and planet concurrently) were consistent with and components of a fiduciary’s obligations (Pivo and McNamara, 2005). Papers from Scheer and Woods (2007) and Sayce, Sundberg, and Clements (2010) expanded the debate and refined the application of these concepts to the commercial real estate markets. Additional papers helped to frame and suggest how to measure sustainability in real estate. For example, Ellison and Brown (2011) advanced a number of metrics for consideration on resource efficiency, locational advantages, and design quality, while Batty (2006), Fellows (2006), Heywood and Kenley (2008), Pivo and McNamara (2008), and Eichholtz, Kok, and Quigley (2010) each worked to illustrate the complex tradeoffs that individuals, firms, and governments need to grapple with when integrating sustainability into real estate investment and development decisions.

Relative to the assessment of sustainability’s value proposition, there is substantial evidence that sustainability creates competitive advantage across nearly all asset classes in the real estate market. Competitive advantage in a multiplicity of forms has been observed in single-family housing (Aroul and Hanz, 2011, Bloom, Nobe, and Bloom, 2011; Rauterkus, 2011), in multi-family housing (Pivo, 2014; Bond and Devine, 2016), in the office market (Miller, Spivey, and Florance, 2008, Eichholtz, Kok, and Quigley, 2010; Wiley, Benefield, and Johnson, 2010; Holtermans and Kok, 2017), and in industrial property (Harrison and Seiler, 2011). Recently, Devine and Chang (2017) identified competitive advantages for sustainable retail property. Together, these and other related papers have revealed that sustainability in real estate is associated with superior asset values, premium rents (although not rent rate growth premiums), attractiveness to capital markets, advantageous technologies generating operational economies, lower occupant churn, and the need to offer fewer incentives to attract and retain tenants.

In addition to the value proposition of sustainable real estate, researchers have also examined the role of public policy in facilitating the growth of sustainability in the real estate markets. Simons, Choi, and Simons (2009) and Kontokosta (2011) studied the factors associated with the spread of public policies supportive of green buildings. They observed that market, climate factors, patent activity, carbon emissions, and political climate were significant predictors of public policy related to green building. Simcoe and Toffel (2014) identified positive spillover effects from public policy decisions on the development of sustainable real estate. In investigations of the technology decisions of U.S. homebuilders, Koebel et al. (2015) and Sanderford, Keefe, Koebel, and McCoy (2015) found that public policy
positively influenced builders’ choices to select sustainable versions of products over traditional economic substitutes (e.g., windows). Bond and Devine (2016) presented similar findings.

Conceptually connecting sustainability and innovation, several studies have focused on sustainability as an innovation in the property markets. Two in particular identified eco-certifications such as LEED and ENERGY STAR as property market innovations and examined how these innovations diffused across the housing and commercial real estate markets. In an analysis of the factors that shaped the adoption of eco-certifications in U.S. housing markets, Sanderford, McCoy, and Keefe (2017) observed positive effects from different types of public policies. With respect to commercial real estate, Kok, McGraw, and Quigley (2011) were surprised not to find a relation between the adoption of sustainable building certifications across U.S. office markets.

Sustainability and innovation districts also intersect in the sustainable real estate literature through the public-private partnerships used to fund high density, mixed-use, urban development projects. These co-investment strategies are a means of sharing the risk of constructing, maintaining, and operating physical assets and urban infrastructure (Indegaard, 2003). The use of public-private partnerships in the realm of local economic development reflects recent urban population growth and the locational efficiencies and advantages associated with the clustering of individuals and firms (McGuirk, 2005). Moreover, the literature suggests that public-private partnerships can be used to meet the space demands of knowledge-based industries (Nelson, 2015). However, and critically for innovation districts, the evidence also suggests that municipal investments in speculative, mixed-use real estate development projects have an inconsistent track record (Frank and Pivo, 1994; Joseph and Chaskin, 2010).

Agglomeration Economics & Economic Development

The study of innovation districts is also intimately related to co-location or agglomeration economies from which they trace their roots (Marshall, 1890, 1920; Rosenthal and Strange, 2001, 2004). This work focuses on spatial measurement relations such as Zipf’s law (e.g., Gabaix and Ioannides, 2004; Holmes and Lee, 2010) and productivity phenomena such as labor pooling (e.g., Baumgardner, 1988; Krugman, 1991; Becker and Murphy, 1992; Rosenthal and Strange, 2004). Building from this and other similar work, innovation district advocates argue that these projects create physical and transactional space for innovation to occur and as a result are more economically resilient than other forms of compact urban development (Katz and Wagner, 2014). [Economic resilience is taken here to mean the ability to withstand exogenous shocks, to adapt to market cyclicality, and to recover quickly in the wake of large shocks (Sánchez et al., 2017).] The economic resilience of innovation districts stems from the ability to create synergies between people, firms, and places (Katz and Wagner, 2014), enabling what Chesbrough (2004) describes as open “innovation” or innovation generated outside of pathways internal to a firm or enterprise.

Agglomeration economics are at the heart of many knowledge-based urban development strategies (Benneworth and Ratinho, 2014; Florida, 2014) including
planned commercial and industrial districts (Markusen, 1996; Raco, 1999), cluster development theory (Porter, 2000; Motomaya, 2008), and research, science, and technology parks of many different shapes and sizes (Link and Scott, 1997; Hansson, Husted, and Vestergaard, 2005; Ratinho and Henriques, 2010). However, not all agglomeration theory maps clearly to innovation district development. For example, Kolko (2010) found that service industries such as finance, insurance, and consulting tend to be less agglomerated although more heavily urbanized, suggesting that there may be industry- and market-specific patterns that influence how and where these firms choose to locate, as well as how they engage with others around innovation, or what Schumpeter (1939) called “creative destruction.”

Although innovation districts trace their roots to agglomeration economics, advocates have placed more emphasis on urban design, policy interventions, and public-private partnerships as a means of catalyzing knowledge-intensive businesses (Sharma, 2012; Wilson, 2014). Modern iterations appear to purposefully bring together entrepreneurial start-ups, established corporations, venture capital providers, universities, and economic development agencies in targeted geographic areas, while using design features consistent with the principles of new urbanism to encourage them to interact in formal and informal ways in attractive common areas, onsite retail outlets, shared-use facilities, and co-work space (Read, 2016). Advocates have argued that the amalgamation of these features helps to differentiate innovation districts from other related economic development strategies (Katz and Wagner, 2014).

The idea that urban areas serve as collision points for innovative people as embodied in the innovation district thesis has been discussed throughout the economic development and innovation literature. For example, Rogers (1995) highlighted the role of social systems as vectors for facilitating increased innovation diffusion. Hall (1995) related the idea of social systems to the city, arguing that cities can serve as a milieu in which innovation can thrive (Crevoisier, 2004). Florida (2002, 2014) expanded Hall and Rogers’ arguments in his exegesis of the creative class positing that the denser the city, specifically with respect to individuals engaged in knowledge-based work, the more frequent the exchange of ideas. As sub-components of cities constructed to stimulate interactions between both knowledge-intensive firms and the people they employ, innovation districts highlight the connections between sustainable real estate and economic development. Innovation districts have the potential to create durable competitive advantage via design, place, and density of people (Chatterji, Glaeser, and Kerr, 2013; Beneworth and Ratinho, 2014).

**Innovation District Risks & Connections**

Embedded in the potential to create this competitive advantage, is the risk of attracting a synergistic mix of tenants and knowledge workers. In the context of labor portability in knowledge-centered economies (Tabuchi and Yoshida, 2000), this risk could be amplified. Commercial real estate owners and operators have grappled with similar issues of inclusion and exclusion when attempting to
optimize the tenant mix of innovation districts, just as they do in all other real estate development projects to maximize economic returns (Sirmans and Guidry, 1993; Grenadier, 1995; Gerbich, 1998). At present, strong prevailing demand among knowledge workers for jobs and housing in dense, mixed-use, walkable environments potentially helps mitigate this risk (Yigitcanlar and Velibeyoglu, 2008).

An additional innovation district risk, perhaps more of a question of capacity, surrounds the potential of these projects to inject social benefits across the economic spectrum, not simply at the high end. Given the focus on knowledge-oriented businesses, innovation districts have the theoretical potential to serve as economic catalysts much in the same way large firms create economic multiplier effects through their need for service provision (e.g., supplies, logistics, and proximate food and beverage options). As a result, it is plausible to expect that innovation districts could create new demand for retail amenities, service sector job opportunities, and improve access to technology (Kauffman, 1995; Pearson, Henryks, Trott, and Jones, 2011). However, despite these theoretical connections, it remains unclear as to whether these projects tend to prioritize or create positive social spillover effects (Wilson, 2014; Almirall et al., 2016; Griffith, 2016).

The types of questions illustrated by Wilson (2014), Almirall et al. (2016), and Griffith (2016) suggest a research opportunity. Innovation district advocates have drawn together the theoretical and practical connections between innovation districts and urban design, real estate, typologies of innovation, and agglomeration (Katz and Wagner, 2014). They have argued that innovation districts have the capacity to address opportunities in social, economic, and environmental terms. However, what appears to be missing from the literature is an examination of how professionals responsible for the planning, development, and operation of innovation districts perceive their projects. More specifically, to what do these professionals attribute their projects’ successes and how does sustainability and its constituent components play a role in those successes? We address these questions in this paper.

**Data and Methodology**

The innovation district case studies presented in this section help provide context about whether those involved in their planning and development conceptualized these projects as a means of simultaneously advancing a city’s economic, environmental, and social goals, as has been frequently suggested in the extant literature. This overarching research question is addressed using data collected through a series of semi-structured interviews with individuals involved in four innovation district projects across the U.S. (Exhibit 1). The cases were selected because they all have characteristics consistent with modern innovation districts as described in the literature. For example, they are all products of public-private real estate development partnerships formed between profit-driven developers, university-affiliated entities, and local governments to accommodate the development of mixed-use environments. Furthermore, they all seek to foster innovation by encouraging formal and informal collisions between highly-skilled
Exhibit 1 | Innovation Districts Selected for Case Study Analysis

1. Cortex is an innovation district officially created in 2002 when BJC HealthCare, the Missouri Botanical Garden, St. Louis University, University of Missouri, and Washington University jointly provided $25 million in funding to begin planning activities and land assembly on approximately 200 acres of land in Midtown St. Louis. Over one million square feet of commercial space has already been constructed on the site and the project is anticipated to include over 4.5 million square feet at completion, owned and managed by various private sector real estate development interests and equity partners. It was started with the explicit purpose of helping the City attract and retain innovative firms in the biotech and life sciences industries.

2. SkySong is the product of a partnership between Arizona State University, the ASU Foundation for a New American University, and the City of Scottsdale formed in 2005 to redevelop a defunct shopping mall located on 42 acres of land into a vibrant innovation district serving the needs of technology-driven firms. It will include over 1.2 million square feet of commercial space at buildout, a significant amount of which has already been delivered to the market. A 325-unit apartment complex and 12,000 square foot of retail space compliment office and research facilities occupied by both private firms and ASU-affiliated entities. All of these buildings are investor-owned. The project was initiated in improve connectivity between ASU and the IT industry.

3. Tech Center at Oyster Point is an innovation district in very early stages of development. A Whole Foods-anchored shopping center and 288 units of apartments have already been completed by private sector real estate developers, with office and lab space scheduled to break ground in the summer of 2017 on a greenfield site immediately adjacent to the Thomas Jefferson National Accelerator Facility. The entire project is anticipated to include over one million square feet of commercial space at completion. Employees of Virginia Tech Corporate Research Center, a successful university research park, were retained on a fee basis to manage and lease the office and lab space, as well as develop programming to help growing firms. The project received public support in the hopes that it would contribute to entrepreneurship in an area well known for its historic dependence on the military and federal government contracts.

4. Technology Square is a 1.3+ million square foot innovation district in Atlanta, scheduled to grow dramatically in the near future with the completion of a new mixed-use tower including a combination of lab, office, and retail space. The first phase of the project was completed in 2003 to help Georgia Tech connect its urban campus to the thriving Midtown business district. A combination of public and private financing was used to complete the project in partnership with a private sector developer. In addition to street level retail, the project houses Georgia Tech’s Scheller College of Business and a number of corporate innovation centers, along with co-work space for start-up business and the various service providers and financiers that support them. Commercializing technology developed at Georgia Tech was one of the primary objectives.

people working in a variety of different capacities. This places them squarely under the umbrella of innovation-oriented real estate development strategies for the purposes of exploratory empirical analysis despite the fact that they vary in scale, scope, location, stage of development, and tenant mix.

The interview data were analyzed using a generalized inductive approach (Thomas, 2006) that was chosen for three reasons. First, qualitative research methods are increasingly being used in exploratory studies of the built environment when rich data are needed to obtain an in-depth understanding of a
particular phenomenon in a context-specific setting (Levy and Peterson, 2013). Second, the approach allows researchers to consolidate raw data easily, to identify common themes present in the data, and to develop a framework to summarize the insights generated from the analysis (Gibson and Barkham, 2001; Levy, 2006; Thomas, 2006; Manning, Weinstein, and Seal, 2007; Heacock and Hollander, 2011). Third, case studies involving semi-structured interviews have proven to be an effective tool to examine the perceptions of real estate practitioners and the professionals they work with in a conversational manner, allowing researchers to probe into issues of interest (Levy, 2013; Palm, 2016; Parker, 2016).

Purposive sampling was used to select the interviewees, which is appropriate when there is a need to ensure those participating in a research project have sufficient knowledge of a real estate issue or transaction (Gallimore, Hansz, and Gray, 2000; Dixon, Pottinger, and Jordan, 2005; Levy and Peterson, 2013). The interview subjects can be divided into five categories for descriptive purposes. As summarized in Exhibit 2, eight of these individuals represented university-affiliated entities or research centers, nine represented third-party firms retained to provide brokerage, design, or consulting services, six represented local governments in executive, economic development, or urban planning roles, six represented nonprofit economic development agencies, and eleven represented real estate development or investment interests. One or more interviewees in each of these categories offered commentary on each of the innovation districts to ensure public, private, and nonprofit perspectives were considered. The full sample was comprised of 28 men and 12 women, all of who were relatively seasoned professionals with multiple years of work experience in their respective fields.
Exhibit 3 | Prompt Questions Guiding the Semi-Structured Interviews

1. Please provide a brief description of the general characteristics of the innovation district development in which you were involved.

2. Please describe the public and private sector parties involved in the development of the aforementioned project to the best of your understanding. Who were the key stakeholders?

3. Who is the target market for the aforementioned project in terms of both tenants and customers? How is the project positioned to serve the target market?

4. What stakeholder groups were influential throughout the development process and how did they influence the project? How was input from these groups solicited or obtained? In what ways were the interests of these groups complimentary or competing?

5. Were any features of the project specifically intended to benefit entrepreneurial firms or start-up enterprises? Were any features of the project intended to provide flexibility to respond to evolving market conditions or consumer preferences?

6. Were any design features of the project intended to encourage the diffusion of ideas or knowledge across tenants or residents? Were any features of the project intended to promote socioeconomic diversity in the tenant or resident mix?

7. Were any design features or management practices incorporated into the project to promote ecological sustainability? What factors motivated these decisions?

8. What factors do you deem critically important to the ongoing success of the project from a real estate investment perspective? What factors pose the greatest threats?

9. What factors do you deem critically important to the ongoing success of the project from an economic development perspective? What factors pose the greatest threats?

10. Are there any best practices you would suggest to other municipalities or real estate practitioners interested in participating in the development of “innovation districts”?

The ten prompt questions presented in Exhibit 3 were emailed to all of the research participants for review before the formal interview. In the aggregate, the questions were designed to gain a better understanding of each person’s role in the planning and/or development of one of the innovation districts of interest, as well as his or her perceptions about factors to which they attributed project successes. Interviewees were additionally asked to describe any design features or management practice they felt were included in the project to promote entrepreneurial activity, socioeconomic diversity, or environmentally-oriented design. The open-ended nature of the prompt questions, coupled with probing follow-up questions put forth by the research team, allowed the interviewees to expand upon these ideas and their conceptualization of innovation districts over the course of interviews that typically lasted around one hour. Naturally, the specificity and amount of the questions were limited by time constraints and by the knowledge bases of both the interviewees and interviewers (Anderson, 2010).

Interview Results

The interview results were systematically reviewed to identify common themes in the data related to innovation district development and its perceived ability
to promote economic resilience, environmental sustainability, and social responsibility. When interpreting the data, emphasis was placed on gaining insight into how those participating in the research conceptualized the projects of interest and how, if at all, they perceived sustainability elements as determinants of success and facilitators of innovation. Broadly, interviewees provided insight suggesting that sustainability played a significant role in the innovation districts on which each worked. More specifically, the results point to a hierarchical emphasis on the components of sustainability as a concept. Interviewees painted a consistent picture where economic attributes of sustainability (e.g., resilience) were given primacy as factors associated with project success. Both environmental and social elements of sustainability were given less emphasis in project discussions, although it was apparent that these components were still factors contributing to project successes.

**Economic Resilience**

Interviewees participating in the planning and development of SkySong and Technology Square offered rather strong support for the contention that innovation districts can be more resilient to economic downturns than other types of development. Commercial real estate brokers familiar with these projects opined that both weathered the global financial crisis of the late 2000s extremely well, outperforming a majority of their peers in terms of occupancy levels maintained and effective rental rates achieved. The latter project was even reported to experience positive absorption during this challenging period due to a “flight to quality” among firms capable of upgrading their facilities. These outcomes were attributed to a combination of factors. Tenants operating in the information technology sector were reported to exhibit strong demand for space near major research institutions, irrespective of whether they were directly involved in research and development activities themselves. This group of tenants was also reported to value proximity to other companies engaging in knowledge-driven enterprises even if those enterprises were in a completely different line of business. These perceptions are consistent with the innovation district thesis and suggest opportunities for open innovation may be capitalized into real estate rents.

Cortex Innovation Community and Tech Center at Oyster Point are still taking shape, but the fact that these projects came to fruition at all was cited by a number of interviewees as a testament to the innovation district concept. In both cases, real estate developers were said to have tried for many years to bring more traditional research and technology parks out of the ground on these particular sites, only to fail. Investors and tenants did not become interested in the idea until the right groups of real estate practitioners and institutional partners proposed the construction of mixed-use environments replete with programming and services catering to the unique needs of innovative firms. Members of the commercial real estate brokerage community familiar with these projects expected them to prove more economically resilient than many of their competitors moving forward as a result of such characteristics.

When asked to describe the factors contributing to the economic success of the innovation district with which they were familiar, interviewees frequently
acknowledged the importance of compact, mixed-use design as a means of attracting knowledge workers and knowledge-based companies to a project. However, they cautioned against relying exclusively on such features to spur interaction and the exchange of ideas. Impactful programming offered on a regular basis was generally perceived to be a more effective and efficient avenue to achieve these ends. Targeted networking events, product and service showcases, CEO roundtables, and executive training programs sponsored by an innovation district’s institutional partners, existing tenants, or property/asset management teams were just a few of the examples put forth to stimulate knowledge diffusion. The fact that this type of programming was highlighted in all four of the cases indicates that it is an essential component of the innovation ecosystem regardless of a project’s location, the different knowledge-intensive businesses served, or the physical environment in which they operate.

Interviewees also noted that innovation districts must be large enough and flexible enough to encourage a significant number of companies in different lifecycle stages to co-locate, while including attractive common areas and public events space to bring outsiders onsite to collaborate. Leveraging the resources of institutional partners was identified as one way of achieving these goals. In all of the cases except Tech Center at Oyster Point, academic institutions stepped forward to master lease space and/or guarantee debt financing in order to procure private sector investment in the development of multi-tenant office and lab facilities serving a diverse tenant mix. Sophisticated operators of co-work space were engaged to provide opportunities in these buildings not only for start-ups, but also established global companies interested in establishing a presence near young and innovative firms. Both non-profit and profit-driven service providers were additionally attracted to these buildings to help start-ups commercialize their intellectual property.

Perhaps unsurprisingly, innovation districts were generally conceptualized in a manner very similar to other types of real estate development involving cross-sector collaboration. Public-private partnerships were perceived as a means of mobilizing parties capable of effectuating change, speculative investments in real estate development were seen as a legitimate use of government resources, and place branding strategies were identified as a useful tool to attract financial and human capital to targeted geographic areas in the name of sustainable economic development. Furthermore, a significant amount of attention was devoted to the importance of adhering to sound real estate development principles, establishing a market-driven vision, and empowering effective private sector leadership to keep all of the parties involved in these complex real estate/economic development transactions moving in the same direction.

The interviews also yielded some evidence that innovation districts differ from other knowledge-based economic development strategies in that their power is not perceived to stem from agglomeration economies alone. Rather, the success of these projects was expected to hinge to no small degree on the implementation of effective governance structures and purposeful efforts to coordinate the activities of knowledge-generating agents in the public, private, and non-profit sectors. Risk sharing and shifting among parties in all of these sectors was additionally seen as
Innovation districts were generally perceived to be more economically resilient than traditional office parks due to their ability to better satisfy the demands of tenants in knowledge-intensive industries.

Key advantages were reported to include proximity to research institutions and other technology-oriented enterprises, impactful onsite programming encouraging interactions between highly-skilled individuals and their employers, and the ability to accommodate companies in different lifecycle stages.

Financial commitments and guarantees provided by institutional partners and local governments were perceived to be important to allow real estate development sufficient in scale to promote collaboration among individuals and organizations operating in a diverse array of industries.

Mission and vision-driven strategies, adherence to sound real estate development principles, and the effective use of branding and promotion were all identified as factors critical to success.

Effective governance structures and thoughtful risk sharing/shifting were anticipated to be necessary to align the disparate interests of all of the parties involved in these transactions.

Environmental Focus

Although environmental sustainability manifested itself in a variety of different ways across the four cases, very few of the interviewees spoke of clearly defined environmental goals established at the front end of a transaction. Resource conservation efforts were more often described as opportunistic and case specific in nature, driven by a combination of market demands, corporate social responsibility commitments, and municipal land use policies and practices. These factors were perceived to define the parameters for incorporating “green” features into a project as summarized in Exhibit 5.

A majority of the interviewees acknowledged that growing market demand for space in urban areas created opportunities to construct innovation districts on infill sites. This was perceived to be environmentally advantageous to the extent adaptive reuse projects prevented the conversion of greenfield sites into traditional suburban office parks or limited development in areas poorly linked to public transportation networks or existing public infrastructure. However, several also contended that settings ripe for innovation could be constructed in areas exhibiting a diverse array of density levels in their land use patterns. The cases themselves illustrated the point. Cortex and Technology Square were both urban infill projects, whereas SkySong involved the adaptive reuse of a suburban site and Tech Center at Oyster Point the development on a greenfield site. The urbanity of a proposed development site was generally believed to be of less importance than its proximity to anchor institutions, such as universities and research centers, amenities, housing options, and supportive public infrastructure.
Reported efforts to promote environment sustainability were often opportunistic in nature and responsive
to evolving tenant demands, market conditions, and municipal land use policies and practices.

Site selection decisions were primarily driven by adjacent land uses, nearby amenities, and proximity to
institutional anchors, as opposed to defined efforts to promote infill development or adaptive reuse.

Walkability and access to public transportation were both cited as desirable features catering to the
demands of those working for technology-driven organizations.

Conspicuous commitments to environmental sustainability, including the pursuit of eco-labels, were
observed to satisfy the corporate social responsibility mandates of large firms and government entities.

Mixed-use development was frequently a product of evolving space and capital market conditions rather
than environmental goals established at the beginning of a project.

Pedestrian-friendly design elements and access to public transportation were
typically seen as marketable and environmentally conscious features of innovation
districts contributing to their appeal to knowledge-intensive firms and their
employees. Nonetheless, efforts were made in all of the cases to accommodate automobile usage through the provision of surface and decked parking at ratios similar to those offered by competitive buildings. The urban planners interviewed
also noted that the commitment to walkability displayed by these projects was just as attributable to municipal land use regulations, urban design guidelines, and
negotiated concessions as it was to market demand or an interest in promoting
impromptu collisions among knowledge workers.

Conspicuous efforts to promote the environmental attributes of sustainability, such as LEED certification, were often seen as a way of satisfying the demands of universities, government agencies, and large corporations much more so than those of relatively small entrepreneurial firms. Nowhere was this more apparent than in Tech Center at Oyster Point where members of the development team noted that a conscious decision was made to design efficient buildings and common areas
without pursuing LEED certification because the branding dimension of sustainability was not perceived to be as important to the tenants they sought to
attract as other features. Members of the commercial real estate brokerage
community working in the four markets where the innovation districts were
located echoed this sentiment to different degrees, while noting that demand for impactful sustainability was on the rise among tenants in most knowledge-based industries.

The mixed-use characteristics of the innovation districts studied were reported to
evolve over time in opportunistic ways separate and apart from environmental
policy goals. Multifamily housing and retail space were not incorporated into SkySong’s original design, but were included as the project evolved in response
to favorable capital market conditions and a need to better amenitize the existing office and lab space. A significant amount of land in the Cortex district was
dedicated to big box retail only after IKEA expressed an interest in the location. Greater efforts were made to activate common areas and streetscapes in
Social policy goals were infrequently cited as motivating factors for the decisions made throughout the planning and development of the projects studied.

Attracting social responsible companies and organizations to an innovation district was often perceived to translate into social benefits for the city in which it was located through nondescript channels.

Market demand stimulated by the development of an innovation district was perceived to create a risk of displacing start-up firms and low/moderate income residents in the absence of mitigating forces.

Retail amenities included in projects were generally perceived to cater to the unique demands of highly-skilled and highly-educated people working onsite, as opposed to underserved indigenous populations.

Potential social benefits received rather little attention in comparison to proposed economic benefits and were rarely touted to obtain public support for an innovation district.

Technology Square several years into its existence to bolster its competitive position. And Tech Center at Oyster Point came to fruition only because policymakers allowed investors to lead with the development of a lifestyle shopping center before constructing any space for knowledge-intensive firms. These examples suggest mixed-use development in innovation districts is pliable and shaped by market forces. Importantly, the emphasis on both the spatial attributes of sustainability (e.g., walkability, mixed-use compact urban form) and the environmental design attributes of projects suggest that market participants perceived the environmental elements of projects to be attributes of success. The emphasis further indicated that sustainability was in demand in a diverse set of market.

**Social Responsibility**

The interviews offered little evidence to suggest that a desire to promote socially responsible real estate development was a driving force behind the innovation districts studied, as noted in Exhibit 6. In fact, several of the interviewees stated that the social dimensions of the projects they participated in were not discussed in any meaningful way during the planning process and did not influence project outcomes in significant ways. Cortex represents the most notable exception, where over $150 million in public subsidies were made contingent on compliance with workforce participation requirements targeting historically underrepresented groups such as women and minorities. The master developers of the project also went on to form a diversity and inclusion committee and sought opportunities for children attending public school in the area to access the technology and makerspaces available onsite. Interviewees involved in the other innovation districts cited few concrete examples of social responsibility initiatives and often noted it was an ongoing conversation.

Interestingly, several of the interviewees seemed to believe attracting socially responsible companies to innovation districts would, in and of itself, translate into greater social equity in the areas where they were located. Those expressing this position cited efforts on the part of non-profits to provide workforce training to
economically disadvantaged parties and improve their access to technology, but they generally had difficulty describing the mechanisms through which profit-driven firms might engage in similar activities. Some of the interviewees also noted that efforts were still underway to figure out how social responsibility might fit into the brand promise of an innovation district to help attract desirable tenants and knowledge workers.

None of the innovation districts in the study are located in heavily populated areas, which limited concerns about gentrification. However, individuals participating in the development of the more established projects acknowledged that real estate values were going up in the areas surrounding them, making it difficult to acquire land for the development of housing serving low- and moderate-income residents. Escalating real estate values were also noted in some instances to create challenges for start-up companies ready to transition out of incubator space into their own facilities. These comments suggested innovation districts could become victims of their own success in terms of their ability to promote economic sustainability and long-run social equity.

The retail amenities included in these innovation districts were rarely lauded by the interviewees for their responsiveness to the needs of underserved populations. Rather, emphasis was more frequently placed on the importance of satisfying the unique and discerning consumer demands of highly-skilled and highly-educated people working in knowledge-based industries. Bars, restaurants, entertainment venues, and specialty retailers targeting this market segment were therefore incorporated into mixed-use environments to further differentiate these projects from competitors. Infrastructure investments such as public transportation upgrades and public park expansions were posited to serve broader socioeconomic groups, but few comments were put forth to suggest community interests consistently influenced the prioritization of such investments.

It is important to note that the majority of statements made by the interviewees did not support a contention that the social benefits of innovation districts were overstated to sway public opinion. Alternatively, such benefits appear to have been given little consideration at all because they were perceived to be outside the scope of an innovation district’s primary objectives. Only two of the urban planners interviewed, as well as two of the real estate developers, questioned whether more could have been done in their respective projects to promote social equity. And even in these instances, they acknowledged that social elements had little impact on planning and development decisions in their innovation districts.

Conclusion

Innovation districts connect a number of research threads germane to sustainable real estate. Conceptually, innovation districts link broad conversations about the role and power of innovation to real estate and economic development. That innovation districts, frequently planned and developed as compact, transit proximate, walkable real estate projects with eco-certified buildings, have been identified as a connection between discussions of sustainability and innovation is
logical. Imagining the transformative potential of these projects is natural. However, small numbers of completed projects and a paucity of data on how those professionals involved in their planning, development, and operation perceive their success and the role of sustainability therein, have limited the exploration of this topic.

Drawing on a set of 40 semi-structured interviews with professionals involved in the planning, development, and operation of four innovation districts in the U.S., this exploratory paper started to address this gap in the literature. This paper is focused on Cortex in St. Louis, Missouri, SkySong in Scottsdale, Arizona, Tech Center at Oyster Point in Newport News, Virginia, and Technology Square in Atlanta, Georgia. These cases were chosen for their alignment with definitions observed in the literature and their stage of life. Each represented a public-private partnership formed between a profit-driven developer, university-affiliated entity, and local government. Further, each is a mixed-use project focused on attracting knowledge industry firms and employees.

The interview data were analyzed using a general inductive approach. Broadly, the results suggest that professionals see sustainability as a factor associated with the success of innovation district real estate projects and a facilitator of innovation. However, consistent with the fact that innovation districts are both economic development strategies and real estate development projects, the interviewees gave economic attributes of sustainability primacy in explaining the successes of their innovation districts. Although the professionals emphasized the social and environmental attributes of projects to a lesser extent, it was evident that they were seen as important project elements. The sustainability components received less attention, which confirmed an important aphorism about sustainability; that is, “it’s complicated.” The observations about market demand for corporate social responsibility, compact mixed-use urban design, and environmentally-oriented building design suggest that even though they were not equally emphasized, these factors are in demand in the market and part of the apparatus that urged projects towards success.

The insights from this group of professionals have implications for innovation district development practice and research moving forward. With respect to practice, those keen to advance a systematic and sustainable approach to economic and real estate development focused on innovation would do well to consider economic competitiveness-based marketing and justification strategies. Although social and environmental issues are critical components of these projects, perhaps developers and public officials should consider framing their benefits in ways that connect them to the project’s ability to be economically resilient and competitive to firms and employees; something that can be accomplished with the growing literature on the value proposition of sustainable real estate.

With respect to research, the findings suggest that more work is necessary to explore how the insights from these professionals correspond and relate to those working on new and emerging innovation district projects. Further, although the paper did not focus on the demand for sustainability, the findings suggest that exploring this topic for its alignment with the narrative across other property types noted in the sustainable real estate literature would be most welcome.
While the findings help articulate some important ideas and next steps, they are also limited. The project may be limited by the bounded rationality of the researchers and interviewees. Such limits are present in similar types of research. However, as natural parts of the exploratory process, purposeful sampling techniques and systematic analytical strategies help to attenuate their effects.

Finally, the results recall the reflection from Hall (1998) on the market, human, and policy challenges of creating contexts for innovation to flourish. In his final discussion of the city as an innovative milieu, Hall concluded that the social and physical systems needed to catalyze innovation can be made neither easily nor to order. Innovation can be a powerful elixir for urban places, but it can also be difficult to tease out. Creating the conditions for innovation to thrive involve a complex alchemy of risk taking, technical expertise, opportunity, and artistic sensitivity blended together in social and market contexts. Based on the insights provided by the interviewees, it seems, sustainability can be additive to this process.

References


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The Quadruple Bottom Line: Tenant Views of Corporate Responsibility in Green Office Buildings

Author
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Abstract
This research expands the traditional triple bottom line (people, profit, and planet) paradigm (Elkington, 1998) by considering how consumer (tenant) and producer (landlord) stakeholders realize benefit in the profit component, particularly in the sustainable real estate industry. Thus, one focus of this research is to provide support for splitting the profit component in the triple bottom line paradigm, thus adding a fourth P. The proposed quadruple bottom line (PPPP) includes the traditional importance of the general environmental goals (planet) and the firm’s employees (people), but splits the traditional profit category into the tenant firm’s profitability (profit T) and landlord firm’s profit (profit L), based largely on lease structure and how potential utility savings are realized.

The diverse lease structure of commercial real estate allows either tenants or landlords to benefit from potential resource savings, depending on the structure of the lease. In a triple net (NNN) lease, the tenant pays all costs associated with...
a building and would realize the full amount of any energy savings. In a full-service gross (FSG) lease, the landlord generally bears all utility costs and realizes any energy savings. The potentially opposing motivations of the tenant and landlord are widely known as the split incentive problem (Heinzle, Yip, and Xing, 2013; Gabe and Rehm, 2014). The split incentive issue has demonstrated market inefficiencies that suggest deeper exploration.

There is a spectrum of lease types in between, loosely called modified gross, in which the costs and benefits are more evenly distributed between the tenant and landlord. In green office buildings, the issue of resource savings associated with structural enhancement goes beyond the split incentive issue as it may contribute to an overall corporate social responsibility (CSR) policy (Hebb, Hamilton, and Hachigian, 2010).

This study, based on a survey of corporate tenants, covers tenant perspectives and the relative PPPP weights of 18 green office-building attributes, initially developed through a series of focus groups (Simons, Robinson, and Lee, 2014) in several large office markets in the United States. The survey was sent to over 3,000 tenants in a nationally representative sample. Of these, 708 usable responses were obtained, a response rate of 23%. Detailed results including a test of internal and external validity can be found in Robinson, Simons, Lee, and Kern (2016).

The results show the importance of disaggregating profit into landlord profit and tenant profit as a way of delving into the split incentive issue and behavioral motivations. Moving beyond solely the profit motive, the findings also indicate that people, and potentially their related productivity and occupants’ well-being, are the tenant respondents’ highest priority. Tenant priority leads, followed by the combined profits for the tenant and landlord, with the planet also scoring high as a priority outside the tenant firm’s direct benefit.

The other main finding of this research is that tenants are highly concerned about the people that work in their space, as well as productivity-related issues. This underscores the importance of employees relative to more altruistic goals (such as the planet). Further, green features that could enhance employee productivity could dominate tenant priorities going forward, and outweigh potential utility savings.

The findings may be most useful for guiding the construction, development, and management of sustainable buildings, as tenant respondents indicate a preference for employee productivity-related features, such as enhanced indoor air quality and better access to daylight. Therefore, highly-valued employee productivity-related features might generate greater financial returns, and are largely unrelated to FSG or NNN lease structure. This may have implications for the scope of items to be addressed in the emerging topic of “green leases.” This research also seeks to contribute to the CSR literature by offering yet another reason for making sustainability a focus, not only for owners but for tenants as well.

The paper begins with a review of literature on corporate social responsibility and green office buildings. Data collection procedures, analytical results, and findings follow. The final section provides conclusions and directions for future research.
Literature Review

Corporate Social Responsibility

In the past half-century, the concept of corporate social responsibility (CSR) has grown exponentially. In the management literature, CSR-related publications have seen a substantial increase since 2003 (Alcañiz, Herrera, Pérez, and Alcami, 2010). Today, corporations are faced with varying stakeholder claims, and a multitude of ways of attacking sustainability issues. With this reality in mind, corporations identify new approaches to sustainability that address their local and consumer needs (Searcy, 2012).

In business, CSR plays a role in continuously increasing an organization’s improvement of social, environmental, and economic performance. According to Business for Social Responsibility, shareholders, analysts, regulators, activists, labor unions, employees, community organizations, and news media are asking companies to be accountable for an ever-changing set of CSR issues. CSR is now perceived as a necessary step toward being financially successful, while also achieving ethical and value-based milestones, such as setting and achieving environmental performance goals, community engagement, and providing benefits to stakeholders (McWilliams and Siegel, 2001). These components are in line with the quadruple bottom line proposed here.

Recent surveys have shown a tremendous increase in companies’ commitment to sustainable business practices. Businesses are investing both time and money to prepare for an increasingly competitive landscape, regulatory uncertainty, and economic volatility. According to Haanaes (2012), organizations need to create buy-in from their constituencies, which can take time, but is well worth the effort and, over time, enhances their profitability.

Many potential links between financial success and sustainability exist. However, it is difficult to quantify and contingent on a number of parameters, and materiality, which can be difficult to detect and tends to be limited to measures designed to increase eco-efficiency (Salzmann, 2005). According to Pryshlakivsky and Searcy (2015), as a corporation delves into the sustainability realm, there are trade-offs that involve the efficient or inefficient use of resources, and the resultant increased or decreased sustainability results. Ho, Wang, and Vitell (2012) argue that companies may move past the profit motive into the People and planet areas, which are major components of the traditional triple bottom line. In this context, we expand the triple bottom line (people, profit, and planet) paradigm of sustainable office buildings by splitting profit into two categories: profit for tenants and profit for landlords.

Profit in CSR

While current research has shown that CSR is no longer strictly profit-focused, there is evidence suggesting that it has economic potential that remains to be fully realized or explored (Schaltegger and Hörisch, 2017). Bloomberg (2010) sees CSR
somewhat differently: they change the word responsibility (which is described as being something you need to do) and replace it with opportunity (something you want to do). Possessing a better understanding of profit is clearly an opportunity.

According to Fisk (2010), conducting business in a manner that is environmentally beneficial to both people and the planet is not mutually exclusive to profitable growth, since businesses can simultaneously both grow and be environmentally friendly. According to Bloomberg (2012), corporate professionals find that focusing on the business bottom line, which is inclusive of the responsible use of natural resources and environmental impacts, can deliver varying value. Interestingly enough, it has been demonstrated that being green is no longer a costly add-on. Rather, it adds value and improves productivity when effectively practiced.

Change can be both incremental and radical, with each decision maker’s actions affecting the world, literally, one energy-efficient light bulb at a time. Business is in a uniquely powerful position to influence change, either through new technologies, markets or by examining past practice in new ways, but business agents of change need motivation to do so (Fisk, 2010). A more in-depth understanding of exactly what profit is, and which entity is benefiting, can provide precisely the motivation business decision makers need.

**Green Construction and Leases**

The sustainability literature in real estate represents a microcosm of the larger CSR business literature. Here, sustainable property represents a component of CSR, recognizing that corporations require various property owners to improve environmental and social conditions, while also preventing undue harm. By shifting an organization’s focus to sustainable developments, they subsequently increase the benefits provided to corporate citizens, whether in owned or leased properties (Laposa and Villupuram, 2010). Such sustainable initiatives can result in large economic advantages for the academy, industry, and government in terms of energy usage in the commercial real estate sector, by achieving an estimated 30% reduction of energy consumption in office buildings (Pachauri and Reisinger, 2007).

A survey of corporate real estate executives indicated that 57% are now involved in funding sustainable investments, 49% are adding sustainability staff, 44% rate suppliers’ sustainability, and 53% indicate improved communications with senior management directly, resulting from sustainability initiatives (Laposa and Villupuram, 2010). The roles of corporate real estate executives in justifying management and operations of properties to benefit the environment are challenging to implement when they interfere with a firm’s business needs (Roper and Beard, 2006).

A complex system of environmental ratings has emerged in the building arena, and the importance of incorporating building efficiency into capital improvements for properties is gaining respect (Reed and Wilkinson, 2005). Demand for green buildings is high in both the commercial sector (Robinson and Sanderford, 2016)
and the residential sector (Aroul and Hansz, 2012), and this translates to a price premium in many cases, as described below.

For the landlords and tenants who embrace the trend towards being green, there are substantial opportunities for long-term financial gain. Additionally, according to Das, Tidwell, and Ziobrowski (2011), green office properties appear to command rental rate premiums over similar non-green buildings.

Canova (2013) suggests that a new leasing instrument would have to be developed, one that encompasses and capitalizes on the benefits of green construction and operation. Generally, there are three types of lease structures in the office market: full service gross (landlord pays all expenses, including energy and water); triple net (NNN, where tenant pays all expenses); and modified gross (a combination of gross and NNN lease types).

Research has been conducted that seeks to identify what drives real estate investors’ interest in sustainable real estate. According to Falkenback, Lindholm, and Schleich (2010), there was a corporate-level driver where a green label generates image benefits, and a property-level driver comprised of higher rental income, lower costs, decreased risks, and higher property values.

Corporate sustainability for individual businesses is also intertwined with the buildings they occupy. Furthermore, trends are beginning to indicate that small-scale single-issue sustainability efforts are no longer considered as socially acceptable as they have been. This trend has been leading to a re-evaluation of the tenant-landlord relationship, in which tenants need more power in negotiating terms such as lease length and building features (Hamilton, Lim, and McCluskey, 2006; Sayce, Sundberg, Parnell, and Cowling, 2009).

Hebb, Hamilton, and Hachigian (2010) note that institutional investors are becoming progressively more interested in commercial buildings that have displayed a commitment to environmental, social, and governance factors, such as reducing their environmental footprints, managing their relationships with key stakeholders (e.g., employees, customers, suppliers, community members, etc.), and leadership’s ethical and political practices. Similar research has shown that rental premiums, derived from green buildings, are dynamic and may provide owners a hedge during down markets (Das, Tidwell, and Ziobrowski, 2011).

Currently, industry leaders and non-profits are leading the green building movement (Eichholtz, Kok, and Quigley, 2009). These organizations are most ready and willing to pay the required rental premiums, realizing they will recoup their costs through energy savings in the long term. Tenants have also shown a willingness to pay premiums for green buildings and their features (Robinson, Simons, and Lee, 2016). Fuerst and McAllister (2009) found that buildings with ENERGY STAR or LEED certifications came with a 6% rental premium. Office rental premiums have been positively related to higher environmental impact scores (Fuerst, 2011). These findings have been consistent over time (Reichardt, Fuerst, Rottke, and Zietz, 2012).

Recent research has shown that tenants, with and without green experience, are willing to pay more for green features and environmental performance factors in
residential buildings (Chau, Tse, and Chung, 2010). Similarly, organizational tenants have recently begun to display a desire for green leases that would improve the overall environmental performance within commercial buildings. The Australian government spearheaded the development of the Green Lease Schedule, which is a contractual agreement between tenants and landlords in reference to setting environmental performance goals for both parties (Hinnells et al., 2008).

In the U.S., over half of commercial buildings operate under a gross lease, meaning that tenants are charged for both their own energy costs, as well as the energy costs of common areas, but gain no direct savings from energy conservation (Brooks, 2008). This absorption of costs by the landlord can make it difficult for tenants to be overly concerned with their own energy savings, but many have started banding together and demanding revisions to lease structures. However, for many tenants, the concept and primary components of a green lease are murky (Sayce, Sundberg, Parnell, and Cowling, 2009). Our aim is to address this concern through a survey of tenants’ understanding of the perceived beneficiaries of the fruits of office real estate leases.

**Data Gathering Procedures**

**Survey Process**

The data were collected in summer 2014 using an online survey available to tenants in 329 U.S. office buildings managed by CB Richard Ellis (CBRE). The instrument and in particular the list of green features was derived from seven focus groups in four geographically diverse cities (49 participants) conducted as part of the Real Green Research Challenge Grant program (Simons, Robinson, and Lee, 2014). The focus was on which specific green features were valued by real estate market participants, which included brokers, tenant reps, building managers, architects, tenants, and project managers. The focus groups for each area were identical in content and purpose, and all but one was in person (the last one was webinar-based).

The final survey instrument was pre-tested for time (target of 15–20 minutes), item terminology, form, and content. Respondents initially received a survey notification email from their building manager. The invitation to participate from the authors came a day later and contained a greeting, general introduction to the research study, a survey link, and mentioned the chance to win a tablet device. The survey instrument included an informed consent page (required by the university’s IRB), where respondents were assured that their responses were confidential. Standard survey techniques were applied, except that question order was not varied due to the need for natural topical flow and in some cases incorporation of conditional logic. Survey data were collected over a four-month period, and respondents were reminded up to four times. Overall, 3,015 tenants were invited to participate, and 708 provided complete responses, for a response rate of 23%. Exhibit 1 contains a map of respondents’ locations.
<table>
<thead>
<tr>
<th>Region</th>
<th># of Buildings</th>
<th>Building % Total</th>
<th># of Tenants</th>
<th>Tenant % Total</th>
<th># of Complete Responses</th>
<th>Respondent % of Total</th>
<th>Response Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mideast</td>
<td>17</td>
<td>5%</td>
<td>202</td>
<td>7%</td>
<td>22</td>
<td>3%</td>
<td>11%</td>
</tr>
<tr>
<td>Southeast</td>
<td>28</td>
<td>9%</td>
<td>229</td>
<td>8%</td>
<td>61</td>
<td>9%</td>
<td>27%</td>
</tr>
<tr>
<td>Great Lakes</td>
<td>43</td>
<td>13%</td>
<td>398</td>
<td>13%</td>
<td>98</td>
<td>14%</td>
<td>25%</td>
</tr>
<tr>
<td>Energy Belt</td>
<td>79</td>
<td>24%</td>
<td>741</td>
<td>25%</td>
<td>205</td>
<td>29%</td>
<td>28%</td>
</tr>
<tr>
<td>Far West</td>
<td>162</td>
<td>49%</td>
<td>1445</td>
<td>48%</td>
<td>322</td>
<td>45%</td>
<td>22%</td>
</tr>
<tr>
<td>Total</td>
<td>329</td>
<td>100%</td>
<td>3015</td>
<td>100%</td>
<td>708</td>
<td>10%</td>
<td>23%</td>
</tr>
</tbody>
</table>

**Data Collected**

Each survey respondent provided information about his or her firm, as well as personal information. This included the company’s total space in the building, primary industry (e.g., IT, real estate, construction, education, advertising, etc.), primary function (e.g., manufacturing, executive/administrative, sales, etc.), and the number of employees at that office location. Demographics include position and years with the company, education, gender, age, and primary mode of transportation to work.

Respondents were asked about a number of factors outside the scope of the present research, including prioritizing of green office building features, the driving forces behind the company’s decision to locate in its current building, importance of LEED and ENERGY STAR designation, and employee productivity and space utilization issues.
For the questions discussed herein on prioritizing green benefits among the various parties, respondents were asked to identify the relative importance of 18 specific green office building features and then to indicate the relative importance (primary and secondary) of the four P’s: planet, people, tenant profit (T) and landlord profit (L). There was also an open-ended question where respondents could write in details (about 40 respondents had something to add). After this question, respondents were asked, “Do you think green buildings generally benefit: the planet, landlord profit (L), tenant profit (T) and people, with one being the highest ranked recipient of benefit.”

**Background on Survey Respondents**

**Profile of Respondents**

Exhibits 2 and 3 show a breakdown by region and job category of the 708 respondents respectively. The sample was from throughout the U.S.; almost half (45%) of the respondents were from the Far West region, followed by Energy Belt (29%), Great Lakes (14%), and Southeast (9%). Response rates by region were generally about 25%, except for the lower rate in the Mideast (11%).

About 15% of respondents were a president, vice president, chief executive officer, chief financial officer, or chief operating officer. Office managers comprised just over half the respondents. Related research rigorously tests sample validity and shows that the overall responses of office managers, generally involved in the leasing decisions, are not statistically different from those of company principals (Robinson, Simons, Lee, and Kern, 2016). The results for a difference of means
test for leadership and office manager responses show virtually no statistical differences between the groups along key measurement areas. Furthermore, according to another related focus group study, senior real estate executives uniformly agree that “office managers could effectively represent tenant decision makers” (Simons, Robinson, and Lee, 2014).

Although the mean number of employees per tenant was 59, the median number was 17, with several larger tenants inflating the mean. The results also show that 58% of respondents had a bachelor’s or higher degree and 60% had worked for the current company more than six years. More specifically, 35% of respondents had more than 10 years of work experience in the current company. The age of survey respondents was evenly distributed among different age groups, but female respondents accounted for a relatively large portion (69%). In addition, 17% of survey participants (118 companies) belonged to the finance and insurance industry sectors and 11% (78 companies) belonged to the legal service sector. In terms of lease structure, a FSG lease accounts for 53% (370 tenant companies), a NNN lease accounts for 33% (234 companies), with the balance being modified gross leases (Exhibit 3). Lease type was not randomly distributed across markets, as some markets tend to lean towards certain lease structures (Robinson, Simons, and Lee, 2017).

**General Sustainable Behavior**

When asked the general question “Does your company actively promote sustainability?” 57% responded in the affirmative, while 39% answered that their firms did not actively promote sustainability. This compares closely with Laposa and Villupuram (2010), who also found that 57% of firms supported sustainability measures.

However, when respondents were asked about a specific behavior: “Have sustainability initiatives been mentioned at a company meeting within the past 6 months?” only 28% of respondents attended a meeting where sustainability initiatives were discussed in the last six months. This may indicate that when moving from the general to the specific (i.e., unpacking the issue in detail), the results can be substantially different.
**Exhibit 4 | Who Do You Think Green Buildings Generally Benefit (N = 720)**

<table>
<thead>
<tr>
<th>Answer</th>
<th>Total Score</th>
<th>Overall Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planet (environmental issues)</td>
<td>2360</td>
<td>1</td>
</tr>
<tr>
<td>Profit (landlord)</td>
<td>1778</td>
<td>2</td>
</tr>
<tr>
<td>People (e.g., employees)</td>
<td>1679</td>
<td>3</td>
</tr>
<tr>
<td>Profit (tenant company)</td>
<td>1383</td>
<td>4</td>
</tr>
</tbody>
</table>

*Note: Total Score is a sum of the ranked item options. Top positioned options have higher rank.*

**Descriptive PPPP Results**

**Tenant Attitudes toward Beneficiaries of Green Office Building Attributes**

Respondents were asked which P group (planet: environment; people: tenant employees; profit of tenant; and profit of landlord) was the primary beneficiary of green office buildings. The results shown in Exhibit 4 indicate that respondents thought the planet was the main beneficiary of green buildings, followed by landlord profit, people, and tenant profit. The level of support for the leading category was almost double the lowest one. If both profit categories are lumped together (landlord and tenant), profit becomes the leading category. This indicates that there may be a benefit to thinking about the profit components separately. Despite the possibility that part of the increase in overall selection of “profit” could be due to the presence of multiple categories, we believe this signal supports the overall theme of the paper. Additionally, later results show that people-related attributes become most important, which presents a contrast between macro thinking of green buildings and the micro execution.

**The PPPP Priorities of the 18 Attributes of Green Office Buildings**

After the respondents were asked to rank the top 18 green building attributes, they were then asked: “An ideal sustainability initiative generates what is often called a triple bottom line, which means it benefits profit (tenant company or landlord), planet (common environmental issues), and people (employees). Please categorize each featured item’s main and secondary benefit.” The responses were awarded a score of two for main beneficiary, and one for secondary beneficiary. The scores were added and ranked, then normalized (maximum possible score is 708 × 2 = 1,416). For each green office building feature in Exhibit 5, four bars (one for each P) are shown (presented in raw, not normalized, scores). The people category leads in nine green features (indoor air quality, natural light, walkability, localized temperature control, public transportation, fitness center, showers, bike racks, and electric car charging stations by large margins). Planet tops four items (recycling, green cleaning, and water conservation by comfortable margins). Tenant profit
**Exhibit 5** | Bar Graphs of PPPP for 18 Green Features

(1,416 = Top Possible Score)
tops three categories (incentive-based lease structure, energy-efficient lighting, and HVAC most by small margins), with landlord profit leading the LEED and ENERGY STAR designations. Thus, the aggregation of individual attribute results yields group preferences of People, which not only topped the most categories, but also did it by wider margins.

These answers are notably different from the simpler question about green buildings as a whole (Exhibit 4), which favored the planet. Since people equates directly or indirectly to employee productivity, it appears that respondents may be thinking more broadly about the benefits of green features. Some of these findings are in line with literature mentioned by Rabianski, Gibler, Tidwell, and Clements (2009) summarizing a few case studies about different features that appeal to the residents and tenants of a building. Those features include high walkability, public transportation, and access to local services.

Next, the individual rankings of green features, sorted by their PPPP priority, are set forth. Exhibit 6 contains four panels, ranking tenant perceptions of the main beneficiaries of those same 18 specific green attributes, sorted according to the four Ps. The top four ranked items, and their normalized scores, are presented below. The Appendix provides the entire set of results for the total PPPP rankings, sorted by green attribute rather than by PPPP category.

Starting with tenant profitability, the top four items for tenant profit (and their scores were): energy-efficient heating, ventilating, and air conditioning, (HVAC, 28.5, reflecting a raw score of 403 out of a possible score of 1,416, or 28.5%), followed closely by a NNN lease structure (28.2), and energy-efficient lighting (24.0). A distant fourth item was local temperature controls at 16.2.

The top four items for employees/people and their scores were: indoor air quality (67.9, reflecting a raw score of 962 out of a possible score of 1,416), access to natural light in the workspace (64.1), walking access to services and restaurants (54.5), and localized temperature-control system (47.7). These scores are substantially higher than for tenant profit and are shown to be the highest of all four P categories.

By far, the top item for the planet was recycling (score of 57.3), with the other top items of energy-efficient HVAC and lighting, and green cleaning products scoring in the 26.9 to 23.2 range.

Finally, the top item for landlord profit was also energy-efficient HVAC, but it only scored 27.5. Energy-efficient lighting (20.7), LEED (15.5), and ENERGY STAR designation (12.5) were also in the top four items, but with much lower scores.

Overall, energy-efficient lighting and HVAC were in the top group of all lists except that of people. Interestingly, the LEED and ENERGY STAR brands were only highly ranked on landlord lists. The profit: tenant and people lists shared localized temperature control. Of the top six scores (over about 40), five were on the people list and one was on the planet list. This may mean that profit items are lower ranked than first believed, and that at least preferences, if not behavior, are focused on more than the bottom line.
### Exhibit 6 | Top Ranked Attributes and Scores for Tenant, People, Planet, and Landlord

<table>
<thead>
<tr>
<th>Score</th>
<th>Top Ranked Attributes</th>
<th>Score</th>
<th>Top Ranked Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel A: Tenant</td>
<td></td>
<td>Panel B: People</td>
<td></td>
</tr>
<tr>
<td>28.5</td>
<td>Energy-efficient system (electricity and gas)</td>
<td>67.9</td>
<td>Indoor air quality</td>
</tr>
<tr>
<td>28.2</td>
<td>Lease structure that financially rewards tenant conservation of resources</td>
<td>64.1</td>
<td>Access to natural light in work space</td>
</tr>
<tr>
<td>24.0</td>
<td>Energy-efficient lighting system</td>
<td>54.5</td>
<td>Walking access to services and restaurant</td>
</tr>
<tr>
<td>16.2</td>
<td>Localized temperature-control system</td>
<td>47.7</td>
<td>Localized temperature-control system</td>
</tr>
<tr>
<td>12.7</td>
<td>Indoor air quality</td>
<td>40.3</td>
<td>Fitness facility on site</td>
</tr>
<tr>
<td>12.6</td>
<td>Access to natural light in work space</td>
<td>39.5</td>
<td>Public transportation</td>
</tr>
<tr>
<td>10.5</td>
<td>Fitness facility on site</td>
<td>18.3</td>
<td>Shower on-site</td>
</tr>
<tr>
<td>8.5</td>
<td>Recycling provided on site</td>
<td>17.8</td>
<td>Efficient lighting system</td>
</tr>
<tr>
<td>8.3</td>
<td>Walking access to services and restaurants</td>
<td>17.6</td>
<td>Green cleaning products</td>
</tr>
<tr>
<td>8.1</td>
<td>ENERGY STAR designation</td>
<td>14.6</td>
<td>Recycling provided on-site</td>
</tr>
<tr>
<td>6.6</td>
<td>LEED designation</td>
<td>11.7</td>
<td>Bike racks</td>
</tr>
<tr>
<td>6.5</td>
<td>Water conservation systems</td>
<td>4.8</td>
<td>Electric car charging station</td>
</tr>
<tr>
<td>6.5</td>
<td>Public transportation</td>
<td>4.4</td>
<td>Energy-efficient system (electricity and gas)</td>
</tr>
<tr>
<td>3.9</td>
<td>Shower on-site</td>
<td>4.0</td>
<td>ENERGY STAR designation</td>
</tr>
<tr>
<td>2.0</td>
<td>Green cleaning products</td>
<td>3.9</td>
<td>Lease structure that financially rewards tenant conservation of resources</td>
</tr>
<tr>
<td>0.8</td>
<td>Green roof</td>
<td>2.8</td>
<td>LEED designation</td>
</tr>
<tr>
<td>0.8</td>
<td>Bike racks</td>
<td>2.5</td>
<td>LEED designation</td>
</tr>
<tr>
<td>0.6</td>
<td>Electric car charging station</td>
<td>2.1</td>
<td>Green roof</td>
</tr>
<tr>
<td>Panel C: Planet</td>
<td></td>
<td>Panel D: Landlord</td>
<td></td>
</tr>
<tr>
<td>57.3</td>
<td>Recycling provided on-site</td>
<td>27.5</td>
<td>Energy-efficient system (electricity and gas)</td>
</tr>
<tr>
<td>26.9</td>
<td>Energy-efficient system (electricity and gas)</td>
<td>20.7</td>
<td>Energy-efficient lighting system</td>
</tr>
<tr>
<td>23.7</td>
<td>Efficient lighting system</td>
<td>15.5</td>
<td>ENERGY STAR designation</td>
</tr>
<tr>
<td>23.2</td>
<td>Green cleaning products</td>
<td>12.5</td>
<td>LEED designation</td>
</tr>
<tr>
<td>22.1</td>
<td>Water conservation systems</td>
<td>11.1</td>
<td>Water conservation systems</td>
</tr>
<tr>
<td>18.7</td>
<td>Public transportation</td>
<td>8.9</td>
<td>Lease structure that financially rewards tenant conservation of resources</td>
</tr>
<tr>
<td>17.9</td>
<td>Indoor air quality</td>
<td>4.6</td>
<td>Access to natural light in work space</td>
</tr>
<tr>
<td>16.4</td>
<td>Walking access to services and restaurants</td>
<td>7.8</td>
<td>Recycling provided on-site</td>
</tr>
<tr>
<td>16.0</td>
<td>Access to natural light in work space</td>
<td>7.1</td>
<td>Localized temperature-control system</td>
</tr>
<tr>
<td>13.7</td>
<td>ENERGY STAR designation</td>
<td>4.0</td>
<td>Fitness facility on site</td>
</tr>
<tr>
<td>11.5</td>
<td>LEED designation</td>
<td>3.2</td>
<td>Indoor air quality</td>
</tr>
<tr>
<td>7.3</td>
<td>Localized temperature control system</td>
<td>2.3</td>
<td>Walking access to services and restaurant</td>
</tr>
<tr>
<td>7.0</td>
<td>Lease structure that financially rewards tenant conservation of resources</td>
<td>2.2</td>
<td>Shower on-site</td>
</tr>
</tbody>
</table>


**Exhibit 6** (continued)
Top Ranked Attributes and Scores for Tenant, People, Planet, and Landlord

<table>
<thead>
<tr>
<th>Score</th>
<th>Top Ranked Attributes</th>
<th>Score</th>
<th>Top Ranked Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Panel C: Planet</td>
<td>Panel D: Landlord</td>
<td></td>
</tr>
<tr>
<td>5.2</td>
<td>Bike racks</td>
<td>1.6</td>
<td>Green cleaning products</td>
</tr>
<tr>
<td>4.3</td>
<td>Green roof</td>
<td>1.4</td>
<td>Public transportation</td>
</tr>
<tr>
<td>3.8</td>
<td>Electric car charging station</td>
<td>1.1</td>
<td>Green roof</td>
</tr>
<tr>
<td>2.0</td>
<td>Fitness facility on site</td>
<td>0.4</td>
<td>Bike racks</td>
</tr>
<tr>
<td>0.8</td>
<td>Shower on-site</td>
<td>0.1</td>
<td>Electric car charging station</td>
</tr>
</tbody>
</table>

Note:

\(\text{a} \% \text{ of possible}\)

---

**Tenant Attitudes Based on Type of Lease Structure**

If landlord and tenant profit motives are different, that difference should manifest in responses to questions that affect their company’s bottom line. To test this hypothesis, two tenant groups, one possessing FSG leases, the other possessing NNN leases, were asked to categorize several resource conservation areas into their primary PPPP. Since those tenants on NNN leases are responsible for all utility costs, the logical expectation is that profit: tenant would be of greater importance to them (i.e., they would have a higher mean ranking of primary importance). Conversely, conservation on the part of FSG leaseholders generally benefits their landlords.

As shown in Exhibit 7, tenants with NNN leases have a statistically significant higher mean score for energy-efficient lighting, energy-efficient HVAC, and efficient temperature control. The mean is higher in all cases but an ENERGY STAR designation for NNN tenants, but not with statistical significance.

The results of the difference of means test further suggest perceptual differences for those who have the ability to affect the company’s bottom line through their energy conservation behavior (benefiting the tenant) versus those who do not (energy savings benefiting the landlord). This supports the notion that tenant and landlord profit should be considered separately.

---

**Conclusions and Future Research**

In this paper, we propose an expansion of the traditional triple bottom line paradigm to incorporate the question of who benefits from resource savings, by exploring tenant priorities in the quadruple bottom line (PPPP), for U.S. office buildings. The survey of 708 institutional office tenants during 2014 covered tenant perspectives and the relative PPPP weights of 18 green office building
**Exhibit 7 | Means Test for Differences in FSG and NNN Leases**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Lease Type</th>
<th>Mean</th>
<th>Mean Difference</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy-efficient lighting</td>
<td>NNN</td>
<td>0.803</td>
<td>0.2088</td>
<td>0.002**</td>
</tr>
<tr>
<td></td>
<td>FSG</td>
<td>0.595</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy-efficient HVAC</td>
<td>NNN</td>
<td>0.846</td>
<td>0.1380</td>
<td>0.030*</td>
</tr>
<tr>
<td></td>
<td>FSG</td>
<td>0.708</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENERGY STAR</td>
<td>NNN</td>
<td>0.209</td>
<td>−0.0014</td>
<td>0.488</td>
</tr>
<tr>
<td></td>
<td>FSG</td>
<td>0.211</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lease structure rewards tenant conservation of resources</td>
<td>NNN</td>
<td>0.799</td>
<td>0.0586</td>
<td>0.237</td>
</tr>
<tr>
<td></td>
<td>FSG</td>
<td>0.741</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficient temperature control</td>
<td>NNN</td>
<td>0.521</td>
<td>0.0997</td>
<td>0.030*</td>
</tr>
<tr>
<td></td>
<td>FSG</td>
<td>0.422</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficient water consumption</td>
<td>NNN</td>
<td>0.162</td>
<td>0.0056</td>
<td>0.885</td>
</tr>
<tr>
<td></td>
<td>FSG</td>
<td>0.157</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: A one-tailed test is used to examine differences in means between NNN lease holders, who are expected to value resources for which they pay, and FSG lease holders who do not directly pay for these resources. N = 234 for NNN leases; N = 370 for FSG leases.

*Indicates significance above the 95% confidence level.

**Indicates significance above the 99% confidence level.

attributes. The results support the notion that tenant and landlord profit considerations contain unique and directional benefits, hence provide justification for the fourth P.

Specifically, the results show that tenants’ attitudes toward profit diverge considerably when landlord profit and tenant profit are considered separately. NNN lease tenants, who pay for resources, place more importance on green factors related to utility costs than FSG lease tenants, who do not directly pay for resources. For some green features, most closely aligned with tenant behavior, there is a statistically significant difference between respondents who have the ability to affect the company’s bottom line through their energy conservation behavior (benefit the tenant) versus those who do not (energy savings benefit the landlord). This is an important consideration for investors who are considering new construction or major rehabilitations. Knowing tenants respond favorably to sustainable features that boost productivity, and realizing those same features may provide a hedge against down markets, is an additional catalyst for sustainable construction. Significant bodies of research demonstrate green premiums for green certified buildings; this research suggests the need for more detailed exploration of lease structure behind these premiums and who bears the upfront costs of energy-efficient systems.

In addition to a fourth P, the results indicate that people and their productivity is the highest priority for respondents, followed by the combined profits for tenants...
and landlords, with the planet also scoring high as a common pool good. When examining individual level attributes, respondents suggest that people are the most important, but often indicate planet or profit in the larger sense. This may reflect a “greenwashing” effect, where laypersons associate green buildings with environmental issues, but when critically thinking about the issues come to different conclusions.

Importantly, the results show that people (a proxy for employee productivity) is the most important of the four Ps. This would direct future research to better explore the productivity area. This is especially relevant in the area of sustainable buildings as a guiding principle for future development and research.

Future research should include a closer look at the determinants of sustainable behavior, expanding investigations into stakeholder motivation for profit along a value chain. Future research could build upon the ideas presented here extending the PPPP model into multiple industries. Finally, the reported focus on productivity related features suggest future research into this area as well.

### Appendix

**Total of All PPPP Scores Combined, Sorted by 18 Green Features**

<table>
<thead>
<tr>
<th>Total Score (% of possible)</th>
<th>Attribute</th>
</tr>
</thead>
<tbody>
<tr>
<td>26.5</td>
<td>Indoor air quality</td>
</tr>
<tr>
<td>25.3</td>
<td>Access to natural light in work space</td>
</tr>
<tr>
<td>23.3</td>
<td>Recycling provided on-site</td>
</tr>
<tr>
<td>22.0</td>
<td>Energy-efficient system (electricity and gas)</td>
</tr>
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<td>21.7</td>
<td>Energy-efficient lighting system</td>
</tr>
<tr>
<td>21.2</td>
<td>Walking access to services and restaurants</td>
</tr>
<tr>
<td>20.4</td>
<td>Localized temperature-control system</td>
</tr>
<tr>
<td>16.8</td>
<td>Public transportation</td>
</tr>
<tr>
<td>15.3</td>
<td>Fitness facility on site</td>
</tr>
<tr>
<td>12.2</td>
<td>Lease structure that financially rewards tenant conservation of resources</td>
</tr>
<tr>
<td>11.4</td>
<td>Green cleaning products</td>
</tr>
<tr>
<td>10.9</td>
<td>Water conservation systems</td>
</tr>
<tr>
<td>10.1</td>
<td>ENERGY STAR designation</td>
</tr>
<tr>
<td>8.4</td>
<td>LEED designation</td>
</tr>
<tr>
<td>7.0</td>
<td>Shower on-site</td>
</tr>
<tr>
<td>4.7</td>
<td>Bike racks</td>
</tr>
<tr>
<td>2.4</td>
<td>Electric car charging station</td>
</tr>
<tr>
<td>2.2</td>
<td>Green roof</td>
</tr>
</tbody>
</table>
Endnotes

1 For example, there can be an expense stop that sets the maximum amount to which the landlord pays certain operating expenses. Amounts above the expense stop, if any, are paid by the tenant. Therefore, even in full-service leases, tenants could potentially profit from energy savings. However, we do not address the expense stop in the analyses. While many modified gross forms will result in some benefit to the tenant for resource conservation, the data limited discussion to the two lease types.

2 For some questions, up to 840 partial responses are available, for a response rate of 28%.

3 The sample population surveyed was in all investment-owned properties. Owner-occupied buildings would by definition combine these two categories.

4 Only those green building attributes you selected as most important in a previous question will appear. Thus, due to “question fatigue,” respondents were only asked to rank the top half of their attributes. Those green building features receiving lower numbers of responses were less desirable overall.

5 Several other items scored highly, like fitness center (40.3) and public transportation (39.5).

References


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The Value of Energy Efficiency in the Anchorage Residential Property Market

Authors Dominique J. Pride, Joseph M. Little, and Marc Mueller-Stoffels

Abstract The residential sector is a significant source of carbon dioxide emissions. Improving the energy efficiency of the housing stock can reduce carbon emissions and increase property values. In this paper, we examine whether residential energy efficiency improvements are capitalized into home prices in Anchorage, Alaska. The impact of a residential energy efficiency program on single-family house prices is estimated using both a hedonic pricing framework and a difference-in-differences estimator. The results indicate that participating homes sell for a premium of 4.2% compared to similar properties that did not participate in the program.

In the United States, the residential sector accounts for 21% of total energy consumption and 20% of national CO\(_2\) emissions (Energy Information Administration, 2016). Sustainable real estate can help mitigate the environmental impact of the housing sector (von Paumgartten, 2003; GhaffarianHoseini et al., 2013). Improving the energy efficiency of the housing stock can reduce residential energy consumption leading to a reduction in residential sector CO\(_2\) emissions and the percentage of household income allocated to energy expenditures (Boardman, 2010). Previous green housing studies show that there is a positive relation between residential energy efficiency and property prices, demonstrating that investments in energy efficiency are often compensated through increased transaction prices (Dinan and Miranowski, 1989; Bloom, Nobe, and Nobe, 2011; Kahn and Kok, 2012). However, there have been no studies investigating the impact of energy efficiency on the transaction prices of homes in the Municipality of Anchorage (Anchorage), Alaska market.

In 2008, Alaska policymakers implemented a residential energy efficiency program, the Home Energy Rebate (Rebate) program, with the primary policy objective of reducing household energy costs by incentivizing investment in residential energy efficiency improvements (Dodge, Wiltse, Valentine, 2012; Goldsmith, Pathan, and Wiltse, 2012). Using a sample of over 18,000 home sales in Anchorage from 2008 through 2015, the effect of participation in the Rebate program on home prices in Anchorage is assessed using a hedonic pricing framework. With a hedonic pricing framework, a home’s characteristics are related to its transaction price, controlling for both the time of the sale and geographic location. This method allows for the price premium associated with participating
in the Rebate program to be isolated. Assuming a homebuyer does not place a monetary value on reducing their carbon emissions, the price premium a buyer in the residential property market is willing to pay for an energy-efficient home should be equal to or less than the present value of the expected energy savings over their anticipated tenure in the home.

Homes in cold climates use more energy than homes in more moderate climates (Sivak, 2013). Therefore, improving the energy efficiency of the housing stock in regions with cold climates could have a larger impact on reducing energy consumption and carbon emissions than improving the energy efficiency of the housing stock in regions with more moderate climates. This study fills the gaps in the sustainable real estate literature relative to culture and climate. Most previous research on the value of residential energy efficiency in cold climates has focused on Scandinavian countries (Mandell and Wilhelmsson, 2011; Cerin, Hassel, and Semenova, 2014; Fuerst, Oikarinen, and Harjunen, 2016). Scandinavian countries are culturally different from Alaska. Scandinavian attitudes towards sustainability may differ from those of Alaskans. Additionally, Anchorage has a subarctic climate, whereas the cities in the other cold climate study areas have oceanic or continental climates. Because Anchorage has a colder climate than the cities previously studied, Anchorage residents have greater potential for energy savings by improving the energy efficiency of their homes. The results of this study may have policy implications for housing markets in other cold climate regions.

Anchorage households face high energy costs and a rapidly changing climate. The average annual energy cost for an Anchorage household is 30% above the national average, and average annual household energy consumption in Anchorage is 2.8 times above the national average, largely due to demand for space heating (AHFC, 2014). Space heating accounts for 70% of residential energy consumption in Anchorage compared to the national average of 42% (EIA, 2013; AHFC, 2014). Improving the energy efficiency of the housing stock in Anchorage could significantly reduce CO$_2$ emissions from the state’s residential sector since 40% of the state’s population resides in the municipality (U.S. Census Bureau, 2016). Reducing residential CO$_2$ emissions is important due to the link between anthropogenic CO$_2$ emissions and climate change (IPCC, 2014). The climate in Alaska is warming at a faster rate than the rest of the U.S. as a whole (Chapin et al., 2014). Over the last six decades, the average annual temperature in Alaska increased by 3°F, while the average winter temperature increased by 6°F (ACRC, 2016).

The remainder of the paper is structured as follows. In the next section, we review the literature, and then provide a background section on the study area and the Rebate program. We next discuss the methods, which is followed by a description of the data used and the results. The paper closes with a summary of the study findings and their implications.

**Literature Review**

The body of literature related to energy efficiency and sustainable real estate has continued to grow as public awareness of climate change and sustainability...


Within the larger body of sustainable real estate literature, there is a burgeoning strand of literature on the effect of energy efficiency on residential property prices. One of the earliest studies relating energy efficiency and residential housing prices is Dinan and Miranowski’s (1989) study that found fuel savings resulting from energy efficiency improvements to homes in Des Moines, Iowa are capitalized into the value of the homes. Many subsequent hedonic studies based on residential property markets in the U.S. focus on the price premiums associated with green certification programs such as the ENERGY STAR and the Leadership in Energy and Environmental Design (LEED) programs (Bloom, Nobe, and Nobe, 2011; Kahn and Kok, 2014; Bond and Devine, 2016; Bruegge, Carrion-Flores, and Pope, 2016; Walls, Palmer, Gerarden, and Bak, 2017).

The ENERGY STAR certification program for newly constructed residential homes was created in 1995 by the U.S. Environmental Protection Agency (ENERGY STAR, 2016). A new home must use 30% less energy than a typical newly constructed home to receive the ENERGY STAR label. Bloom, Nobe, and Nobe (2011) find that ENERGY STAR certified homes in Fort Collins, Colorado sell for a price premium of $8.66 per square-foot. Bruegge, Carrion-Flores, and Pope (2016) find that ENERGY STAR certified homes in Gainesville, Florida sell for a price premium between 1.2% and 4.9%. However, this price premium declines over subsequent sales.

The LEED program was created by the U.S. Green Building Council in 1998 and offers certification for properties that meet standards for the green design, construction, operation, and maintenance of buildings (Indiana University Bloomington, 2016). Bond and Devine (2016) examine premiums associated with LEED certified and other green multi-family residential properties across the U.S. The authors find that LEED properties rent for a premium between 8.9% and 9.1%. However, properties that are marketed as green but do not have an official green certification rent for a smaller premium of 4.74%.
There are several hedonic studies on U.S. property markets that investigate the residential property price premium associated with multiple green certification programs. Kahn and Kok (2014) find California homes with green certifications (ENERGY STAR, LEED, or California’s local GreenPoint Rated certifications) sell for a price premium of approximately 5%. When the sample is restricted to the Metropolitan Statistical Areas of Los Angeles, San Diego, and San Francisco and the green certifications are disaggregated, only the premium associated with the ENERGY STAR certification (4.7%) remains statistically significant. Walls, Palmer, Gerarden, and Bak (2017) investigate the price premium associated with the national ENERGY STAR program, as well as local green certification programs. ENERGY STAR certification is associated with a 2% price premium in both the Research Triangle area of North Carolina and the Portland, Oregon markets. The local green certification programs, which have more stringent requirements than the ENERGY STAR program, are associated with a 7% to 8% price premium in Austin, Texas and a 3% price premium in Portland, Oregon.

Outside of the U.S., there are several studies that examine the value of residential energy efficiency in cold climate regions. Cerin, Hassel, and Semenova (2014) investigate whether the energy performance of properties in Sweden affect the values of certified properties. Their results indicate that a 1% increase in energy performance is associated with a 0.06% increase in the transaction price of a property. Mandell and Wilhelmsson (2011) investigate whether homebuyers in Stockholm, Sweden, who claim to be environmentally aware, have a higher willingness to pay for environmentally friendly housing attributes. The results indicate that environmental awareness significantly affects homebuyers’ willingness to pay for home attributes that reduce the consumption of water and energy. Fuerst, Oikarinen, and Harjunen (2016) find that apartments in Helsinki, Finland with the top three energy efficiency ratings sell for a price premium of 3.3%, but this premium decreases to 1.5% when detailed neighborhood characteristics are included in the model.

In addition to hedonic analysis, difference-in-differences (DiD) estimators have also been used to assess the impact of energy efficiency on property prices. The DiD method is popular in policy analysis for estimating the effects of policies that do not affect the whole population at the same time or in the same way (Lechner, 2010). Reichard, Fuerst, Rottke, and Zietz (2012) use both a DiD and fixed-effects model approach to assess the effect of obtaining sustainable building certification on rental prices and occupancy rates of commercial office buildings in the U.S. The results of the DiD estimator analysis indicate that LEED certification has no impact on either rents or occupancy rates, but buildings that received ENERGY STAR certification rent for an average price premium of between 3.3% to 6.1% and have increased occupancy rates. The results of the fixed effects models indicate that ENERGY STAR and LEED certification have statistically significant average rent premiums of 2.5% and 2.9%, respectively.
Background

Study Area

Anchorage is Alaska’s largest city with a population of approximately 300,000 residents (U.S. Census Bureau, 2015). Anchorage has a subarctic climate with a maritime influence, and experiences cold winters and mild, wet summers. The average annual temperature is 3°C (37°F); average daily high temperatures range from −5°C (23°F) in January to 18°C (65°F) in July (ACRC, 2016). Anchorage has 10,570 heating degree days1 (HDD) per year, and the average Anchorage household consumes 171.2 million British thermal units2 (MMBtu) per year for space heating (Information Insights, 2009). By comparison, the region of New England has 6,752 HDD per year and the average household consumes 85.4 MMBtu annually for space heating (Information Insights, 2009). Alaska does not have a mandatory energy efficiency standard, but does have a voluntary energy efficiency certification program, the Building Energy Efficiency Standard (BEES), which was enacted by the state legislature in 1992 (U.S. Department of Energy, 2016).

Home Energy Rebate Program

Alaska’s economy is closely linked to oil price cycles. Alaska does not have a state income tax. Instead, the state receives the majority of its general revenue from taxes on the petroleum industry and oil and gas royalties (Tichotsky, 2014). When oil prices are high, the state has abundant revenue to fund the state budget. However, high oil prices place a burden on households that rely on petroleum-based products for their home energy needs. In an effort to alleviate the burden of high home energy costs, legislation establishing the Rebate program was passed in 2008 (Goldsmith, Pathan, and Wiltse, 2012).

The Rebate program was administered by the Alaska Housing Finance Corporation3 (AHFC) and operated from May 2008 through March 2016 when the program was suspended due to budgetary shortfalls brought about by reduced state revenue resulting from low oil prices (Brehmer, 2016). Through the Rebate program, homeowners could receive a rebate up to $10,000 for making preapproved energy efficiency improvements to their primary residence (AHFC, 2013). Unlike the federally- and state-funded Weatherization Assistance Program aimed at lower-income households, there were no income qualifications for the Rebate program.

To participate in the Rebate program, a homeowner was required to have an initial as-is energy efficiency audit conducted on their home to assess its energy efficiency before any energy efficiency improvements were made. The homeowner had 18 months from the date of as-is energy audit to make recommended improvements and have a post-improvement energy efficiency audit conducted on their home. Program participants paid for the improvements upfront and then received a rebate check after submitting the required paperwork. The amount of
the rebate was based on the increase in the energy efficiency of the property as measured by the increase in energy rating points and star steps between the as-is and post-improvement energy ratings and eligible receipts for contracted labor and materials. Exhibit 1 displays the point value ranges and corresponding energy star ratings for homes. It should be noted that the AHFC’s energy rating scale is not related to the EPA’s ENERGY STAR program. A home’s energy rating could range from 1 star to 6 stars. Moving up the energy efficiency rating scale from a star rating to the next higher star is a step increase. See Exhibit 2 for the maximum possible rebate amounts for step increases. Once a home completed the Rebate program, the property was not eligible to participate in the program again even if it changed owners.

The Alaska State Legislature appropriated over $250 million for the Rebate program from fiscal year 2008 through fiscal year 2015, and nearly 25,000 homeowners across the state participated (Brehmer, 2016). The program was
popular in Anchorage, where approximately 14% (14,690) of occupied housing units completed the program (AHFC, 2014; Waterman, 2016). It is estimated that program participants reduced their annual energy costs by 30% and their residential CO₂ emissions by 35% (Information Insights, 2009). The average rebate received by program participants in the Anchorage area totaled $7,422 (Waterman, 2016).

**Methods**

The hedonic pricing framework is well-established in the real estate literature on energy efficiency (Fuerst and McAllister, 2011; Robinson and McAllister, 2015). Using the hedonic pricing framework, as proposed by Rosen (1974), the transaction price of the home is deconstructed into its constituent characteristics, allowing one to determine the contribution of the individual characteristics to the home’s transaction price.

One criticism of the hedonic framework is that hedonic models are often misspecified by either including irrelevant variables or omitting relevant variables (Chau and Chin, 2003). Including irrelevant variables leads to estimated coefficients that are consistent and unbiased, but inefficient; omitting relevant variables leads to estimated coefficients that are inconsistent and biased. Because hedonic price models deal with the implicit prices of quantities of home attributes, all hedonic models are misspecified to some degree (Butler, 1982; Chau and Chin, 2003). However, as long as the model includes variables for the key attributes of the property (e.g., size, age, etc.), biases due to missing variables have been found to be small (Butler, 1982; Mok, Chan, and Cho, 1995).

**Hedonic Regression Model**

A semi-log model is estimated using a least squares dummy variable (LSDV) approach, relating the transaction price of the home to its physical characteristics, geographic location, time of sale, and participation in the Rebate program:

\[
\ln(\text{price}_i) = \alpha + \beta X_i + \sum_{j=1}^{12} \gamma_j A_j + \sum_{k=1}^{41} \delta_k Q_k + \psi r_i + \epsilon_i. \tag{1}
\]

In equation (1), the dependent variable is the natural log of the selling price of home \(i\) in 2015 dollars; \(\alpha\) is a constant term; \(X_i\) is a vector of hedonic characteristics for home \(i\) including the square footage (Square feet) of the residence in hundreds of square feet, square footage of the residence in hundreds of square feet squared (Square feet²), number of bedrooms (Bedrooms), number of bathrooms (Bathrooms), number of cars a garage can hold (Garage capacity), the age of the home at the time of sale (Age) in years, and the acreage of the property parcel (Acres); \(\epsilon_i\) is a random disturbance term. A set of indicator
variables indicating the Multiple Listing Service (MLS) area number are included to control for geographic effects, such as differences in the availability of public amenities and the varying quality of school districts. \( A_j \) takes a value of one if home \( i \) is located in MLS area number \( j \) and zero otherwise. Indicator variables for the quarter \((Q_k)\) in which the transaction took place are included to control for temporal effects such as changing economic and market conditions over the 32 quarters in the study period. \( Q_k \) has a value of one if home \( i \) was sold in quarter \( k \) and zero otherwise. \( r_i \) is an indicator variable with a value of one if home \( i \) participated in the Rebate program and zero otherwise. \( \alpha, \beta, \gamma, \zeta, \) and \( \psi \) are estimated coefficients. The parameter of interest, \( \psi \), is the average percentage premium estimated for a Rebate participant home.

**Difference-in-Differences Model**

A DiD estimator is used with a sample of homes with repeat sales to assess the average impact of the Rebate program on the transaction prices of homes in Anchorage. The repeat sales sample is divided into a treatment group of homeowners who participated in the Rebate program and a control group of homeowners who did not participate in the Rebate program. Each home in the repeat sale sample sold twice over the study period from 2008 through 2015. At the time of the first sale, none of the homes in the sample had participated in the Rebate program. At the time of the second sale, the homes in the treatment group had undergone an energy efficiency retrofit through the Rebate program.

The initial values of the homes of those who opted into the Rebate program may have differed from the homes of those who did not opt into the program. Using a DiD estimator, it is possible to determine whether there is a significant difference between the values of Rebate participant and non-participant homes before the homes of Rebate participants were retrofitted. It is also possible to capture the price appreciation/depreciation trend in all housing values across the treatment and control groups in Anchorage over the study period.

In the sample, the longest possible time period between a first and second sale is seven years and eleven months since the sample covers home sales from 2008 through 2015. The short time period covered by the sample reduces the probability that homes underwent major renovations between the first and second sale. There is potential that some homes in the sample could have completed energy efficiency retrofits outside of the Weatherization or Rebate programs. However, the Weatherization program offers energy efficiency retrofits free of charge to the homeowner if the homeowner meets the income requirements, while the Rebate program offered cash reimbursement to those who completed the program. Therefore, it seems unlikely that a homeowner would have undertaken a large-scale energy efficiency retrofit without applying to one of the available residential energy efficiency programs that offered financial assistance.

The data for both the first and second home sales and for both Rebate and non-Rebate participants are pooled. The effect of participating in the Rebate program
on the selling price of homes is estimated with the following regression model using a LSDV approach:

\[ \ln(\text{price}_i) = \alpha + \beta X_i + \sum_{j=1}^{12} \gamma_j A_j + \sum_{k=1}^{31} \zeta_k Q_k + \psi \text{Participated}_i + \omega 2\text{ndSale}_i + \delta \text{PostRebate}_i + \epsilon_i. \]  

(2)

In equation (2), the dependent variable is the natural log of the selling price of home \( i \) in 2015 dollars. \( \alpha \) is a constant term, \( X_i \) is a vector of hedonic characteristics of home \( i \) as described above, and \( \epsilon_i \) is a random disturbance term. \( A_j \) are indicator variables taking a value of one if home \( i \) is located in MLS area number \( j \) and zero otherwise. \( Q_k \) are indicator variables taking the value one for the quarter in which home \( i \) was sold and zero otherwise. \( \text{Participated} \) is a group-specific effect to control for the average pre-treatment differences between the treatment and control group. \( \text{PostRebate} \) is an interaction term between \( \text{Participated} \) and \( 2\text{ndSale} \) and indicates whether home \( i \) underwent an energy efficiency retrofit through the Rebate program and was the second sale of home \( i \). \( \text{2ndSale} \) is the time trend. \( \text{2ndSale} \) takes a value of one if the transaction is the second sale of home \( i \) and zero otherwise. \( \psi \) accounts for the differences between homes that did and did not participate in the Rebate program. The parameter \( \omega \) accounts for the changes in all housing values in Anchorage between the first and second sales. The parameter of interest, \( \delta \), measures the impact of participating in the Rebate program on transaction prices of single-family homes:

\[ \delta = (\ln(\text{price}_2)^{\text{Rebate}} - \ln(\text{price}_1)^{\text{Rebate}}) - (\ln(\text{price}_2)^{\text{Non-Rebate}} - \ln(\text{price}_1)^{\text{Non-Rebate}}). \]  

(3)

The DiD estimator in equation (3) measures the difference in the average value of homes that participated in the Rebate program between the first and second sale minus the difference in the average value of homes that did not participate in the Rebate program between the first and second sale. The subscripts 1 and 2 indicate the first and second sale of a property, respectively. The superscripts \( \text{Rebate} \) and \( \text{Non-Rebate} \) indicate the Rebate program participation status of a property.

Data

Data on Anchorage single-family home sales from 2008 through 2015 are from the Alaska MLS. The data include information on the date of the sale and the
selling price of the home. Additionally, the data include information on the hedonic characteristics of the home such as the square footage of the residence, number of bedrooms and bathrooms, whether the home has a garage, the year the home was built, and the acreage of the property parcel.

Data on Rebate program participant properties from 2008 through 2015 are from the Cold Climate Housing Research Center (CCHRC), which manages the Alaska Retrofit Information System database on behalf of the AHFC. The data provided include the physical address of participating homes and the dates of both the as-is and post-improvement energy audit for each participant property. Data on the specific energy efficiency improvements made to the homes were not made available. The addresses of Rebate participants were matched to addresses in Alaska MLS dataset, and homes that sold after they participated in the Rebate program were identified. Exhibit 3 displays the pre- and post-retrofit energy efficiency rating distributions for Anchorage Rebate participants. The average pre-retrofit energy rating for a Rebate participant home in the sample is 3 Stars. After completing the Rebate program, the average post-retrofit energy rating increased to 4 Stars.

In addition to data on Rebate program participants, CCHRC also provided data on Weatherization program participants. Homes that completed the Weatherization program were removed from the dataset because these Weatherization participant homes underwent energy efficiency retrofits and therefore are not an appropriate control group. Additionally, homes that received an as-is energy efficiency audit but did not complete the Rebate program in the 18-month time requirement were also removed from dataset because it is possible that their owners began, but were
Exhibit 4 | Distribution of Housing Transactions

Panel A: Distribution of housing transactions and Rebate transactions by year

<table>
<thead>
<tr>
<th>Year</th>
<th>Rebate Participants</th>
<th>All Homes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percent</td>
</tr>
<tr>
<td>2008</td>
<td>3</td>
<td>0%</td>
</tr>
<tr>
<td>2009</td>
<td>21</td>
<td>1%</td>
</tr>
<tr>
<td>2010</td>
<td>66</td>
<td>5%</td>
</tr>
<tr>
<td>2011</td>
<td>145</td>
<td>10%</td>
</tr>
<tr>
<td>2012</td>
<td>223</td>
<td>15%</td>
</tr>
<tr>
<td>2013</td>
<td>317</td>
<td>22%</td>
</tr>
<tr>
<td>2014</td>
<td>320</td>
<td>22%</td>
</tr>
<tr>
<td>2015</td>
<td>359</td>
<td>25%</td>
</tr>
<tr>
<td>Total</td>
<td>1,454</td>
<td>100%</td>
</tr>
</tbody>
</table>

Panel B: Distribution of housing transactions by MLS area

<table>
<thead>
<tr>
<th>MLS Area</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-Downtown</td>
<td>237</td>
<td>1%</td>
</tr>
<tr>
<td>10-Spendard</td>
<td>1,111</td>
<td>6%</td>
</tr>
<tr>
<td>15-West Tudor Road-Diamond Boulevard</td>
<td>2,336</td>
<td>12%</td>
</tr>
<tr>
<td>20-Dimond South</td>
<td>1,975</td>
<td>11%</td>
</tr>
<tr>
<td>25-Dearmoun Road-Potter Marsh</td>
<td>884</td>
<td>5%</td>
</tr>
<tr>
<td>30-Abbot Road-Dearmoun Road</td>
<td>2,476</td>
<td>13%</td>
</tr>
<tr>
<td>35-East Tudor Road-Abbot Road</td>
<td>1,945</td>
<td>10%</td>
</tr>
<tr>
<td>40-Seward Highway to Bonifacce Parkway</td>
<td>1,236</td>
<td>7%</td>
</tr>
<tr>
<td>45-Bonifacce Parkway to Muldoon Road</td>
<td>2,308</td>
<td>12%</td>
</tr>
<tr>
<td>50-Post Road-Glenn Highway</td>
<td>136</td>
<td>1%</td>
</tr>
<tr>
<td>90-Eagle River</td>
<td>3,123</td>
<td>17%</td>
</tr>
<tr>
<td>100-Chugiak/Peters Creek</td>
<td>762</td>
<td>4%</td>
</tr>
<tr>
<td>101-Girdwood-Turnagain Arm</td>
<td>195</td>
<td>1%</td>
</tr>
<tr>
<td>Total</td>
<td>18,724</td>
<td>100%</td>
</tr>
</tbody>
</table>

Panel C: Distribution of housing transactions by decade of construction

<table>
<thead>
<tr>
<th>Year</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-1950</td>
<td>127</td>
<td>1%</td>
</tr>
<tr>
<td>1950-1959</td>
<td>807</td>
<td>4%</td>
</tr>
<tr>
<td>1960-1969</td>
<td>1,561</td>
<td>8%</td>
</tr>
<tr>
<td>1970-1979</td>
<td>4,041</td>
<td>22%</td>
</tr>
<tr>
<td>1980-1989</td>
<td>5,544</td>
<td>30%</td>
</tr>
</tbody>
</table>
### Exhibit 4 | (continued)

#### Distribution of Housing Transactions

**Panel C: Distribution of housing transactions by decade of construction**

<table>
<thead>
<tr>
<th>Year</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990–1999</td>
<td>2,942</td>
<td>16%</td>
</tr>
<tr>
<td>2000–2009</td>
<td>3,079</td>
<td>16%</td>
</tr>
<tr>
<td>Post-2009</td>
<td>623</td>
<td>3%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>18,724</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

**Panel D: Distribution of housing transactions by participation in the Home Energy Rebate Program**

<table>
<thead>
<tr>
<th>Rebate</th>
<th>Repeat Sample</th>
<th></th>
<th>Full Sample</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percent</td>
<td>Frequency</td>
<td>Percent</td>
</tr>
<tr>
<td>0</td>
<td>5,362</td>
<td>96%</td>
<td>17,270</td>
<td>92%</td>
</tr>
<tr>
<td>1</td>
<td>220</td>
<td>4%</td>
<td>1,454</td>
<td>8%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5,582</strong></td>
<td><strong>100%</strong></td>
<td><strong>18,724</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

unable to complete, the recommended energy efficiency improvements in the allotted 18-month period. Since these homes may have undergone partial energy efficiency retrofits, they are not an appropriate control group. Homes that were less than one year old at the time of sale were removed from the dataset to eliminate new properties from the dataset since the Home Energy Rebate energy efficiency retrofit program was only available for existing homes.

In total there are 18,724 housing transactions in the sample of Anchorage single-family home sales from 2008 through 2015. The distribution of housing transactions by year, Rebate homes sold by year, MLS area, decade of construction, and participation in the Rebate program are displayed in Exhibit 4. Eight percent of total home transactions in the full sample are Rebate participant homes. Exhibit 5 reports the summary statistics for house characteristics for the full sample and the full sample broken out by Rebate program participation.

From the full data set, repeat sales were identified, and 2,791 homes that sold twice over the study period were extracted for a total repeat sales sample of 5,582 sales. Of these 2,791 homes that sold twice, 220 participated in the Rebate program between their first and second sale (see Panel D of Exhibit 4). If a home participated in the Rebate program and the first and second sale of the home occurred after the date of the post-improvement energy audit, the observations were removed from the dataset. If a home sold more than twice over the study period, the two most recent sales were used. However, if a home participated in the Rebate program and sold more than twice, the two sales closest to the date of participation in the Rebate program were used. The repeat sales data are used
### Exhibit 5 | Sample Means

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
<th>Rebate Status</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Full Sample</td>
<td>Repeat Sales</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean</td>
<td>Std. Dev.</td>
<td>Mean</td>
</tr>
<tr>
<td>Price</td>
<td>Transaction price of the property</td>
<td>Whole sample</td>
<td>350,826</td>
<td>150,636</td>
<td>352,346</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rebate = 1</td>
<td>359,950</td>
<td>107,560</td>
<td>353,104</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rebate = 0</td>
<td>350,058</td>
<td>153,690</td>
<td>352,283</td>
</tr>
<tr>
<td>lnPrice</td>
<td>Natural log of transaction price</td>
<td>Whole sample</td>
<td>12.69</td>
<td>0.39</td>
<td>12.69</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rebate = 1</td>
<td>12.76</td>
<td>0.26</td>
<td>12.74</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rebate = 0</td>
<td>12.68</td>
<td>0.39</td>
<td>12.70</td>
</tr>
<tr>
<td>Square feet</td>
<td>Square footage of the residence</td>
<td>Whole sample</td>
<td>2,058</td>
<td>886</td>
<td>2,053</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rebate = 1</td>
<td>2,080</td>
<td>701</td>
<td>2,023</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rebate = 0</td>
<td>2,056</td>
<td>900</td>
<td>2,054</td>
</tr>
<tr>
<td>Bedrooms</td>
<td>Number of bedrooms</td>
<td>Whole sample</td>
<td>3.39</td>
<td>0.81</td>
<td>3.41</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rebate = 1</td>
<td>3.43</td>
<td>0.71</td>
<td>3.46</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rebate = 0</td>
<td>3.38</td>
<td>0.82</td>
<td>3.40</td>
</tr>
<tr>
<td>Bathrooms</td>
<td>Number of bathrooms</td>
<td>Whole sample</td>
<td>2.28</td>
<td>0.73</td>
<td>2.30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rebate = 1</td>
<td>2.30</td>
<td>0.63</td>
<td>2.23</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rebate = 0</td>
<td>2.28</td>
<td>0.74</td>
<td>2.30</td>
</tr>
<tr>
<td>Garage capacity</td>
<td>Number of cars a garage can hold</td>
<td>Whole sample</td>
<td>1.77</td>
<td>0.96</td>
<td>1.78</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rebate = 1</td>
<td>1.78</td>
<td>0.78</td>
<td>1.60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rebate = 0</td>
<td>1.77</td>
<td>0.97</td>
<td>1.81</td>
</tr>
<tr>
<td>Age</td>
<td>Age of property at sale</td>
<td>Whole sample</td>
<td>27.08</td>
<td>14.76</td>
<td>25.78</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rebate = 1</td>
<td>34.80</td>
<td>10.25</td>
<td>35.77</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rebate = 0</td>
<td>26.43</td>
<td>14.90</td>
<td>24.37</td>
</tr>
<tr>
<td>Acres</td>
<td>Acreage of the property</td>
<td>Whole sample</td>
<td>0.34</td>
<td>0.91</td>
<td>0.31</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rebate = 1</td>
<td>0.34</td>
<td>0.40</td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rebate = 0</td>
<td>0.34</td>
<td>0.94</td>
<td>0.31</td>
</tr>
</tbody>
</table>
to estimate a DiD model. The summary statistics for the repeat sales sample are reported in Exhibit 5.

**Results**

Exhibit 6 displays the results of equation (1) estimated with the full sample, along with heteroscedasticity robust standard errors. The temporal and geographic controls are reported in the Appendix. For Model 1, the Rebate price premium is statistically significant at the 1% level, which indicates that a home that participated in the Rebate program sells for an 8.9% price premium over similar single-family homes that did not participate in the Rebate program in Anchorage. At the mean transaction price of $350,826 in the full sample for a single-family residence in Anchorage, the price premium associated with participating in the Rebate program amounts to $31,224.

In Model 1, the coefficients for the hedonic characteristics of homes are all statistically significant at the 5% level and have signs in the expected direction. The model explains 79% of the variation in the transaction prices in homes in Anchorage. Adding an additional 100 square feet to a home increases its selling price by 4% ($14,033). Adding an additional bedroom or bathroom increases a home’s selling price by 1% ($3,508) and 2% ($7,017), respectively. Adding space for an additional car in a garage increases the selling price of a home by 10% ($35,082). Each additional decade of age reduces the price of a property by 4% ($14,033). Adding an additional acre to a property parcel increases the selling price of a property by 2% ($7,017).

The results of equation (2) estimated with the repeat sales sample are reported in Exhibit 6, along with heteroscedasticity robust standard errors in Model 2. In this estimation, Bathrooms is no longer statistically significant. All other coefficients are statistically significant at the 5% level and have the expected sign. The coefficient on Participated indicates that at the time of the first sale, the value of the homes purchased by homeowners who selected into the Rebate program were, on average, worth 3% ($10,570) more before they underwent the energy efficiency retrofit than similar homes whose owners did not select into the Rebate program. The coefficient on 2ndSale indicates that, on average, after controlling for inflation and deflation across the year/quarters, the price of the second sale of homes was 9% ($31,711) greater than the price of the first sale of homes. The variable of interest, PostRebate, indicates that, after controlling for differences in the first sale prices and the price appreciation trend, homes that sold after their owners participated in the Rebate program sold for an average price premium of 4.2% ($14,799) compared to similar homes that did not complete the Rebate program at the mean selling price of $352,346 in the repeat sales sample.

It is possible that homeowners that participated in the Rebate program chose to undertake renovations in addition to the energy efficiency improvements. If that is so, then the DiD model may suffer from omitted variable bias, and some of the 4.2% price premium attributed to participation in the Rebate program could be...
### Exhibit 6 | Results

<table>
<thead>
<tr>
<th></th>
<th>Full Sample</th>
<th>Repeat Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model 1</td>
<td>Model 2</td>
</tr>
<tr>
<td><strong>Participated</strong></td>
<td></td>
<td>0.030**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.011)</td>
</tr>
<tr>
<td><strong>2ndSale</strong></td>
<td></td>
<td>0.087***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.008)</td>
</tr>
<tr>
<td><strong>PostRebate</strong></td>
<td></td>
<td>0.041**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.014)</td>
</tr>
<tr>
<td><strong>Rebate</strong></td>
<td>0.085***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.004)</td>
<td></td>
</tr>
<tr>
<td><strong>Square feet</strong></td>
<td>0.040***</td>
<td>0.041***</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td><strong>Square feet²</strong></td>
<td>−0.000***</td>
<td>−0.000***</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td><strong>Bedrooms</strong></td>
<td>0.010***</td>
<td>0.020***</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.004)</td>
</tr>
<tr>
<td><strong>Bathrooms</strong></td>
<td>0.017***</td>
<td>0.005</td>
</tr>
<tr>
<td></td>
<td>(0.004)</td>
<td>(0.006)</td>
</tr>
<tr>
<td><strong>Garage capacity</strong></td>
<td>0.095***</td>
<td>0.099***</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.005)</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>−0.004***</td>
<td>−0.003***</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td><strong>Acres</strong></td>
<td>0.022**</td>
<td>0.032***</td>
</tr>
<tr>
<td></td>
<td>(0.007)</td>
<td>(0.008)</td>
</tr>
<tr>
<td><strong>Constant</strong></td>
<td>12.151***</td>
<td>12.176***</td>
</tr>
<tr>
<td></td>
<td>(0.026)</td>
<td>(0.045)</td>
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<tr>
<td>$R^2$</td>
<td>0.789</td>
<td>0.823</td>
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**Notes:** The dependent variable is $\ln(\text{Sale Price})$. In Model 1, the number of observations is 18,724; in Model 2, the number of observations is 5,582. Heteroscedasticity robust standard errors are reported in parentheses.

* Significant at the 0.10 level.
** Significant at the 0.05 level.
*** Significant at the 0.01 level.

Attributed to those non-energy efficiency renovations. However, given the 18-month time requirement for the program, it seems unlikely that homeowners would want to undertake additional renovations while on a deadline. Additionally, program participants only received reimbursement for their approved energy
efficiency improvements after they were completed. Thus, taking on additional home renovations beyond the energy efficiency improvements would only increase a homeowner’s upfront costs. Therefore, while it is possible that some Rebate participants made additional renovations to their homes beyond the energy efficiency improvements, the tight time frame for program completion and the high upfront costs of taking on multiple construction projects make this less likely. Lastly, it is likely that some homes in the control group made non-energy related upgrades to their homes over the study period, which may cancel out the effect of non-energy related upgrades in the treatment group. However, there are no data available to examine this possibility.

The premium estimated with the DiD model is smaller than the premium estimated with the hedonic model. In the DiD model, the net premium for those who participated in the program \((Participated + PostRebate)\) is 7.4%, which is close to the premium estimated for Rebate participants in the hedonic model (8.9%). The results of the DiD estimator indicate that part of the premium associated with participating in the Rebate program found in the hedonic analysis can be attributed to the greater initial value of the homes of those who selected into the program. Therefore, the results from DiD model seem more reliable than the results from the hedonic model.

The 4.2% price premium for Rebate properties in the Anchorage market is less than the 15.1%–15.5% price premium estimated in another study for Rebate properties in the Fairbanks, Alaska market (Pride, Little, and Mueller-Stoffels, in review). However, the results of the studies are not comparable because the climate is considerably colder and energy prices are much higher in Fairbanks than in Anchorage.

**Conclusion**

Residential energy efficiency improvements can help reduce the amount of energy required to heat homes, which can save homeowners money on energy costs, reduce residential CO\(_2\) emissions, and increase the transaction price of homes. In this study, we use a hedonic price framework and a DiD estimator to examine the price premium associated with participating in the Rebate program in the Anchorage housing market.

The investment in residential energy efficiency made by Rebate program participants is compensated through a sale price premium. The results show that Anchorage residents value energy efficiency and are willing to pay a premium of 4.2% ($14,799) for energy-efficient homes. These results are in line with the studies described in the literature review that found energy-efficient residences sell or rent at a premium between 1.2% and 9.1% (Kahn and Kok, 2014; Bond and Devine, 2016; Bruegge, Carrion-Flores, and Pope, 2016; Fuerst, Oikarinen, and Harjunen, 2016; Walls, Palmer, Gerarden, and Bak, 2017). However, some of the premiums found in the literature are too low to justify Rebate program-like energy efficiency retrofits. For example, Bruegge, Carrion-Flores, and Pope (2016) found
ENERGY STAR certified homes in Gainesville, Florida sell for a premium as low as 1.2%, which equates to $2,900 at the mean selling price of a home in Gainesville. While the authors found the magnitude of the premium is consistent with the present value of annual energy cost savings for seven years of homeownership, the premium would not justify a $10,000 investment in energy efficiency improvements.

Although the results are specific to homes that participated in the Rebate program, they can be applied more broadly to residential properties in Anchorage that have undergone energy efficiency retrofits. Homeowners who invest in energy efficiency improvements benefit immediately from energy savings stemming from the improvements, and homeowners that sell their homes after making energy efficiency improvements gain the additional benefit of receiving a premium on the selling price. The results indicate that Rebate participants who subsequently sold their homes received a price premium that exceeded the average reported $11,681 investment in energy efficiency paid by program participants (Ord, 2015). The price premium may signal that homebuyers expect energy prices to increase in the future, or that homebuyers in Anchorage place a monetary value on the reduced carbon footprint of energy efficiency properties.

In the absence of the subsidy provided by the Rebate program, investments in energy efficiency still make economic sense for homeowners in Anchorage. Now that the Rebate program has been suspended, the state could provide information on the region-specific expected cost and benefits of various residential energy efficiency improvements to incentivize investment in energy efficiency. This information may be useful to Anchorage homeowners who are ambivalent about pursuing energy efficiency improvements because they are worried about the relative costs and benefits associated with such improvements. This type of information campaign could be useful in other cold climate regions beyond Alaska in markets where price premiums for energy-efficient homes have been demonstrated. If homeowners believe their investment will be compensated, more homeowners may have incentives to undertake energy efficiency retrofits, which would help reduce housing sector CO₂ emissions and improve housing stocks across cold climate regions.

Future research could measure the actual energy savings resulting from energy efficiency improvements. Pre- and post-improvement energy consumption could be measured to estimate average energy savings resulting from energy efficiency retrofits. Energy savings from different categories of energy efficiency improvements such as replacing the home’s heating equipment or improving its insulation could be estimated. Additionally, researchers could compare the value of the energy savings to the price premium paid by homebuyers in the market for energy-efficient homes in Anchorage to learn if the energy savings are capitalized into the value of homes.
## Appendix

### Temporal and Geographic Controls

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<tr>
<th>Period</th>
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<td>(0.015)</td>
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<td>2008:Q4</td>
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<td>-0.002</td>
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<td>(0.017)</td>
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### Temporal and Geographic Controls

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<td>10-Spenard</td>
<td>-0.259***</td>
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### Time Controls

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<td>2015:Q2</td>
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<td>0.032**</td>
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<td>(0.018)</td>
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### Appendix (continued)

**Temporal and Geographic Controls**

<table>
<thead>
<tr>
<th></th>
<th>Full Sample</th>
<th>Repeat Sales</th>
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</thead>
</table>
| 2040-Seward Highway to Boniface Parkway | −0.306***  
(0.023) | −0.371***  
(0.039) |
| 2045-Boniface Parkway to Muldoon Road | −0.374***  
(0.022) | −0.443***  
(0.038) |
| 2050-Poast Road-Glenn Highway | −0.574***  
(0.034) | −0.615***  
(0.058) |
| 2090-Eagle River | −0.328***  
(0.022) | −0.384***  
(0.038) |
| 20100-Chugiak/Peters Creek | −0.389***  
(0.025) | −0.415***  
(0.040) |
| 20101-Girdwood | 0.068**  
(0.026) | 0.027  
(0.043) |

**Notes:**
- *Significant at the 0.10 level.
- **Significant at the 0.05 level.
- ***Significant at the 0.01 level.

### Endnotes

1. Heating degree days are the annual sum of the difference between the average outdoor air temperature over a 24-hour period and a base temperature (typically 65°F) (EIA, 2015).

2. A British thermal unit (Btu) is the amount of work required to raise a pound of water one degree Fahrenheit.

3. The Alaska Housing Finance Corporation is a public corporation that provides affordable loans for housing and administers public and senior housing programs, as well as energy efficiency and weatherization programs.

4. The transformation of $100 \times \beta$ is used for the interpretation of the coefficients for continuous variables due to the model’s log-level functional form (Wooldridge, 2006). However, the transformation of $100 \times [\exp(\beta) - 1]$ is used for the interpretation of the estimated coefficients of indicator variables (Halvorsen and Palmquist, 1980).

### References


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<td>Short-Term Own-Price and Spillover Effects of Distressed Residential Properties: The Case of a Housing Crash</td>
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<td>Gary Pivo &amp; Jeffrey D. Fisher</td>
<td>Income, Value and Returns in Socially Responsible Office Properties</td>
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Journal of Real Estate Portfolio Management
Michael Hudgins

Journal of Real Estate Practice and Education
Drew Sanderford

Journal of Sustainable Real Estate
Kwame Addae-Dapaah
CALL FOR PAPERS
Journal of Sustainable Real Estate

The American Real Estate Society announces a call for papers for the 10th volume of the Journal of Sustainable Real Estate (JOSRE). Authors are encouraged to submit original research that can help investors, developers, appraisers, lenders, asset managers, elected government officials, and land use regulators improve their strategies, decision-making, and understanding of the impact of sustainable real estate practices around the globe. DEADLINE: June 30, 2018.

Manuscript prizes for this volume range from $1,000 to $3,500. Four will be awarded: Best Paper, Developing Markets, Europe, and Asia-Pacific

Topics and potential questions of interest within them include, but are not limited to, the following:

- Corporate Green and Sustainable Strategies and Policies: What are the impacts of corporate policies on leasing, spending, customer acquisition/retention, stock price, and related questions?
- Environmental Contamination and Offsite Effects: How does this factor into sustainable real estate site selection?
- Evaluating the Financial Benefits of Retrofits and Improvements: Can green features be packaged into ideal combinations?
- Financing, Insurance, and Valuation Issues: How do insurance costs vary for sustainable buildings? What financing mechanisms are out there to help with sustainable investments?
- High-Performance Building Systems: Productivity and Design: Can impact of green buildings on worker productivity and morale and other benefits that go beyond energy savings be measured and valued? Do they translate into rent?
- Net Zero and Living Building Challenge: Case studies, strategies, and lessons learned
- Philosophical and Definitional Changes in Green over Time: How have green measurement systems evolved?
- Regulatory Issues Promoting or Inhibiting Real Estate Sustainability: How have disclosure and transparency affected the market? What can we learn from incentive versus requirement systems in terms of effectiveness and efficiency?
- Residential Green and Sustainable Strategies and Policies: What are trends in the diffusion, regulatory impact, resource savings, and consumer preferences in residential real estate?

All papers are subject to anonymous double-blind review by practicing academic faculty and professionals and must be submitted through the electronic submission system for the journal. Manuscripts are only accepted via online submissions and must include a cover letter. Two Word files should be submitted. One file should not contain author names and identifying information. Save this version as Manuscriptwithoutauthorsnames. Another file should contain the title page containing complete contact information for all authors. Questions regarding submissions should be directed to Amelia Caldwell, managing editor, at: A.S.Caldwell@csuohio.edu Please use this link for all manuscript submissions:

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CALL FOR PAPERS

JOURNAL OF HOUSING RESEARCH

The American Real Estate Society announces a call for papers for the Journal of Housing Research (JHR). The objective of the JHR is to serve as an outlet for theoretical and empirical research on a broad range of housing related topics, including but not limited to, the economics of housing markets, residential brokerage, home mortgage finance and mortgage markets, and international housing issues.

All submitted manuscripts are subject to double-blind peer review by members of the journal’s Editorial Board and other real estate scholars and professionals. Preferable word processing format is as a PDF or Microsoft Word file. The JHR style is similar to the Journal of Real Estate Research (see www.aresnet.org or a copy of the journal for a style guide). Final revisions must be in Word, WordPerfect or other acceptable word-processing program.

Manuscripts should be original, unpublished works not under publication consideration anywhere else. Manuscripts should be submitted via the automated author submission system for the journal at: http://www.editorialmanager.com/jhr.

Justin D. Benefield
Auburn University
College of Business
405 W. Magnolia Ave., Suite 303
Auburn, AL 36849
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Call for Papers

Journal of Real Estate Practice and Education

The American Real Estate Society announces a Call for Papers for the Journal of Real Estate Practice and Education (JREPE). The purpose of the JREPE is to motivate research in real estate practice and education and encourage excellence in teaching. It provides a basis for the exchange of innovative opinions and research results among real estate practicing professionals, educators and researchers internationally.

The goal of the Journal is to make a significant advancement in the teaching and learning of real estate practice and education. The contributions from its content will provide an essential source of information on the teaching of real estate and become critical to the understanding of practice and education in the real estate area.

Manuscripts are solicited and encouraged in the following areas:

Practice: Innovations and experiments in all aspects of practice including training and teaching techniques (hardware, materials, technology and methods).

Education: Original empirical and theoretical papers on the evaluation of pedagogy methods, practice, attitudes, materials and learning methods in industry and academia.

Subject Matter: Substantive issues and/or research results that influence the body of knowledge and course content (practice and academia).

Special Features: Special topics such as significant events, curriculum developments, and special surveys.

Four hard copies of the manuscript should be submitted along with an electronic file in Microsoft Word or WordPerfect 6.0. Editorial guidelines printed in a current issue of the Journal of Real Estate Research should be followed. The JREPE is published biannually.

Manuscripts should be submitted via the automated author submission system for the journal at: http://www.editorialmanager.com/jrepe.

William G. Hardin III
Florida International University
Hollo School of Real Estate
1101 Brickell Avenue
Suite 1100-S
Miami, FL 33131
jrepe@fiu.edu
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EDITORIAL POLICY and SUBMISSION GUIDELINES

Mission Statement
The Editors of The Journal of Sustainable Real Estate are dedicated to working with scholars in existing and emerging markets to produce high quality papers to expand knowledge in the field of sustainability and the built environment.

Journal Objectives
The Journal of Sustainable Real Estate (JOSRE) is an official publication of the American Real Estate Society (ARES). JOSRE is committed to publishing the highest quality analytical, empirical, and clinical research that is useful to business decision-makers in the fields of real estate development, economics, finance, investment, law, management, marketing, secondary markets, and valuation. Theoretical papers that fail to provide testable or policy implications are discouraged. Data used in empirical research must be thoroughly documented and sufficient details of computations and methodologies must be provided to allow duplication.

The Editorial Board of JOSRE is interested in expanding the frontiers of scholarly real estate research and is willing to work with any potential author who is developing new and exciting ideas. Please visit http://www.josre.org for the most up-to-date information on the Journal.

Topics and potential questions of interest include, but are not limited to, the following:

- Corporate green and sustainable strategies and policies
- Environmental contamination and offsite effects
- Evaluating financial benefits of retrofits and improvements
- Financing, insurance, and valuation issues
- High-performance building systems; productivity and design
- Net zero and living building challenge case studies, strategies, and lessons learned
- Philosophical and definitional changes in green over time
- Regulatory issues promoting or inhibiting real estate sustainability
- Residential green and sustainable strategies and policies

Policies

Editorial and Review Policies
After a manuscript is submitted, the senior editor reads each submitted manuscript to decide if topic and content of the paper fit the mission and objective of JOSRE. Appropriate fit manuscripts through the desk review process are then assigned by the senior editor to one of the associated co-editors. The associate co-editor upon reading the manuscript then sends the manuscript out for a double-blind peer review process to at least two reviewers. At least one of the blind reviews is an editorial board member.

The associate co-editor upon receiving evaluation form and comments back from reviewers then determines if the paper should be accepted, accepted with major revisions, accepted with minor revisions, or rejected. If there is a split vote, the manuscript may go out to a third reviewer for a tie break. The associate co-editor may also act as the third reviewer solely for the purpose of a tie break, if needed. Once the paper has been resolved, the senior editor confirms the associate co-editor’s decision regarding final decision for publication. The senior editor has final oversight over accepted papers. The senior editor weighs in on and balances when there is a split vote between the blind reviewers. The associate co-editor sends a decision letter that provides the author(s) with blinded reviewer forms, including the original peer review.
Publication Ethics Policy

Two questions are asked to all authors upon submitting a new manuscript via the Allen Press website to JOSRE. 1) Do you attest the work is your own? 2) Have you ever published any portion of this elsewhere? JOSRE requires that the research be original and that the author attests in writing to this statement before proceeding with it being able to submit the paper. The JOSRE ethical policy also does not allow any co-author to be able to review a manuscript.

Copyright Policy

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Article Retraction and Correction Policy

JOSRE relies on our reviewers to vet major issues with the methodology of submissions as well as the associate co-editor’s oversight during the review process. Authors and editors are expected to carefully review final galley proofs. It is a two-step process. Both authors and editors separately are expected to review for errors. Authors and editors have an opportunity to make changes to a manuscript prior to final publication during galley proof stage. If outsiders wish to contest the validity of findings, their brief notes may be published in letter to editor in subsequent issue at the discretion of Senior Editor. This would further allow the original author(s), to respond, should they choose. Papers will only be retracted in the case of verification that the data were falsified. In the unlikely case this were to occur, the matter would be brought before the publication director of ARES to determine if in this case a retraction is warranted. The publication director will determine the next course of action.

Guidelines

Submission Requirements

Authors should submit a manuscript that is double-spaced and paginated. The cover page, which will be removed before the manuscript is sent to a reviewer, should contain: the title, all authors and their affiliations (mailing addresses), phone and fax numbers, and email addresses. Except for the cover page, all pages should be numbered consecutively. Submitted manuscripts should be original research, and the names appearing on the manuscript should be that of the individuals who conducted the research. The manuscript should not be under review simultaneously at another journal nor substantially resemble those that are under review at another journal. Upon acceptance, ARES automatically owns the copyright of the manuscript. The transfer of copyright will ensure the widest possible dissemination of information.

All papers are subject to anonymous double-blind review by practicing academic faculty and professionals. Articles must be written to be understandable by institutional real estate investors. Lengthy formulas and mathematics should appear in an appendix. Applied empirical studies will be given preference.

All online submissions are required to include:
1. Cover letter to the attention of Roby Simons/Senior Editor and Amelia Caldwell/Managing Editor.
2. Article MS Word version as intended layout for publication (with authors names allowed throughout).
3. Article MS Word version as required for blind peer-review process (with all names and identifying information removed from title page, acknowledgements, metadata in file name, etc.). Please save this version as *Manuscriptwoauthorsnames.

If this is author’s first time using the JOSRE web-platform, you will need to create a username and password with Allen Press. Please use this link for all manuscript submissions: http://www.editorialmanager.com/josre/default.aspx. All questions regarding manuscript submission should be directed to Amelia Caldwell at: A.S.Caldwell@csuohio.edu.

Abstract
An abstract of not more than 100 words is required.

Keywords
A minimum of four and maximum of six key words are required to be submitted on title page.

Headings
Primary, secondary, and tertiary heading should be indicated by numbering or in outline fashion (i.e., I, II, A, B, i, ii, etc.). Such outlining/numbering is for editorial purposes only and will not appear in print.

Exhibits
Illustrations must be titled and numbered consecutively as exhibits with Arabic numbers. Please check that the text contains a reference to each exhibit. Verify that all numerical amounts add up to totals shown in the tables and that significant digits are rounded to no more than three numbers. All figures need to be sharp, clear, and laser-quality. Authors are encouraged to utilize color.

Endnotes
Endnotes in the text must be cited consecutively. They should be double-spaced and appear on a separate page. Avoid numerous and lengthy endnotes.

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References must be presented alphabetically by the last name of the author and be double-spaced. References must be dated, and the citations in the text must agree. Only those references cited within the text should be included. The references must fit the following format:


Acknowledgment
Authors may include a brief acknowledgment. It should appear after the references.

Special Note
Authors are strongly advised to review a recent issue of the JOSRE to confirm that their manuscript is in the style the Journal requires.
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